

Biotechnology



We have been manipulating DNA for generations!

- **Artificial breeding/ Selective**
 - ◆ creating new breeds of animals & new crop plants to improve our food



Animal breeding



Rege

Breeding food plants

- **“Descendants” of the wild mustard**
 - ◆ the “Cabbage family”



Breeding food plants



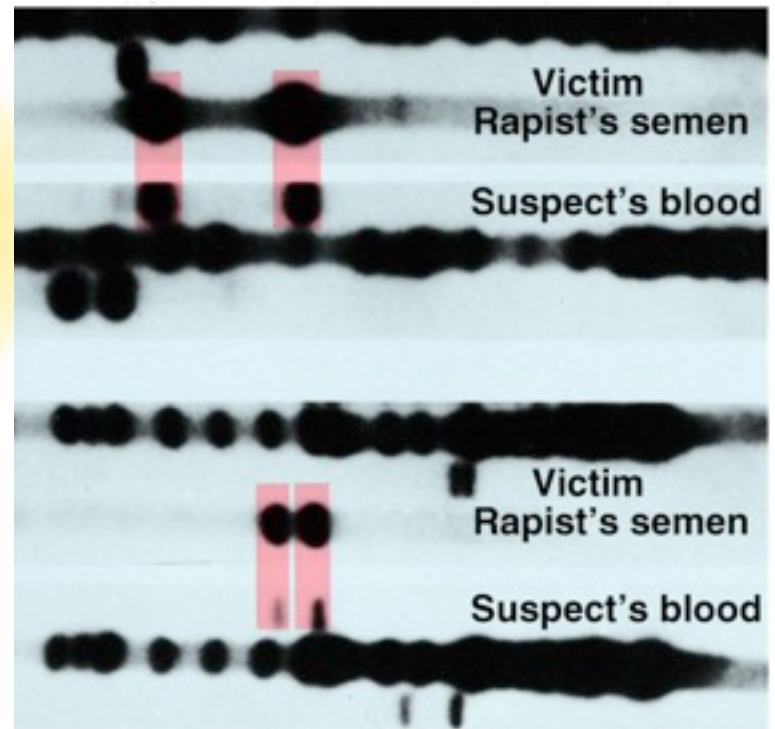
Evolution of modern corn (right) from ancestral teosinte (left).

Rege

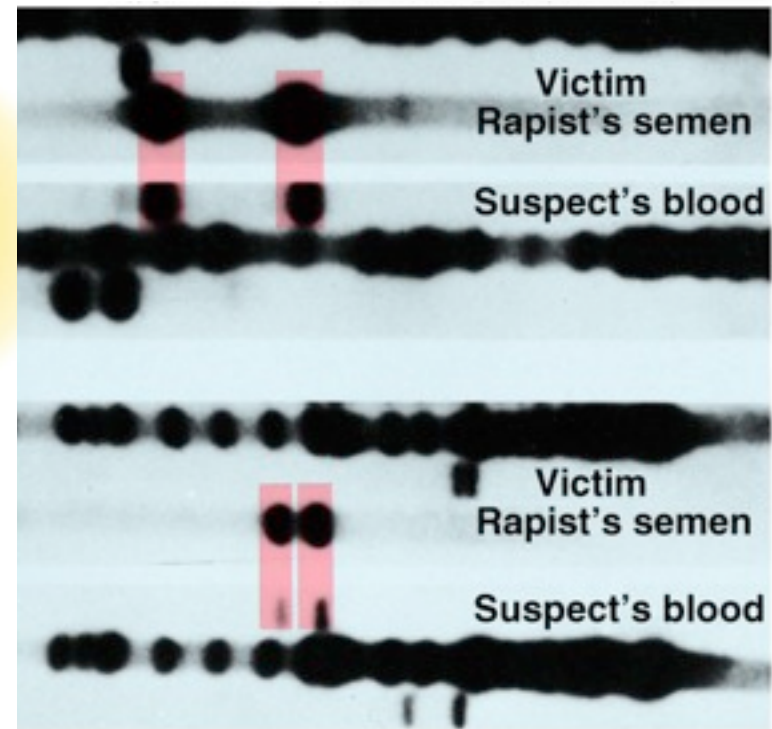
A Brave New World



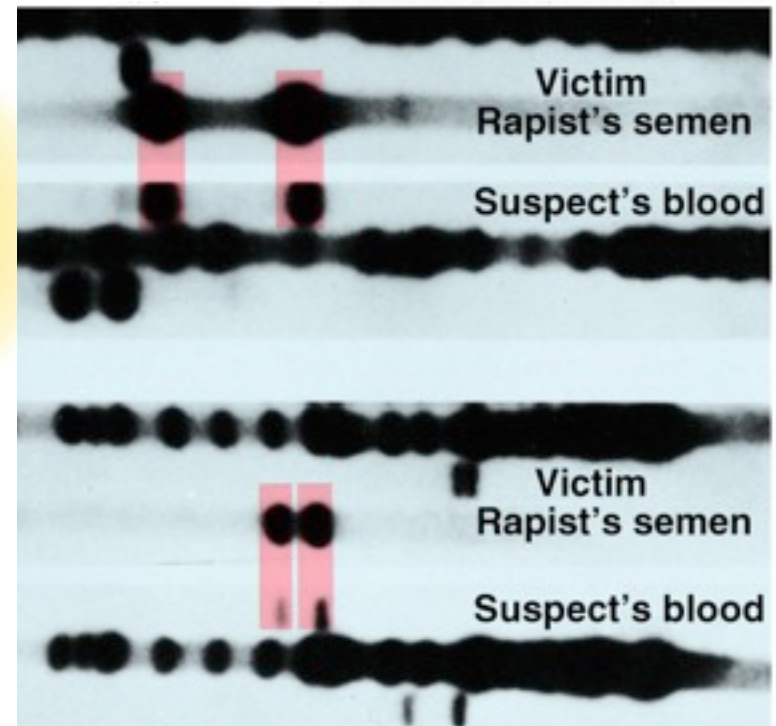
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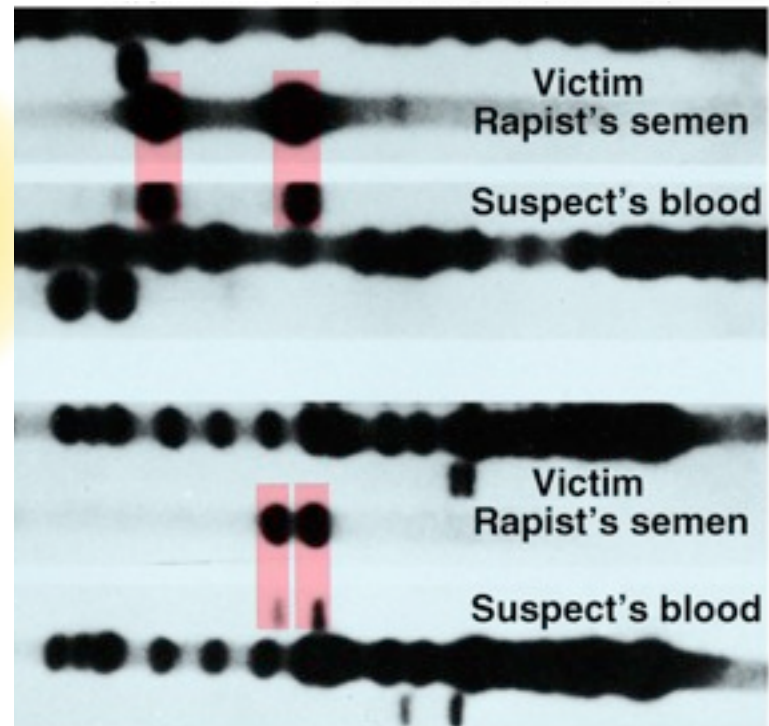
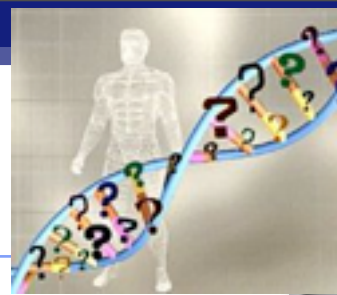
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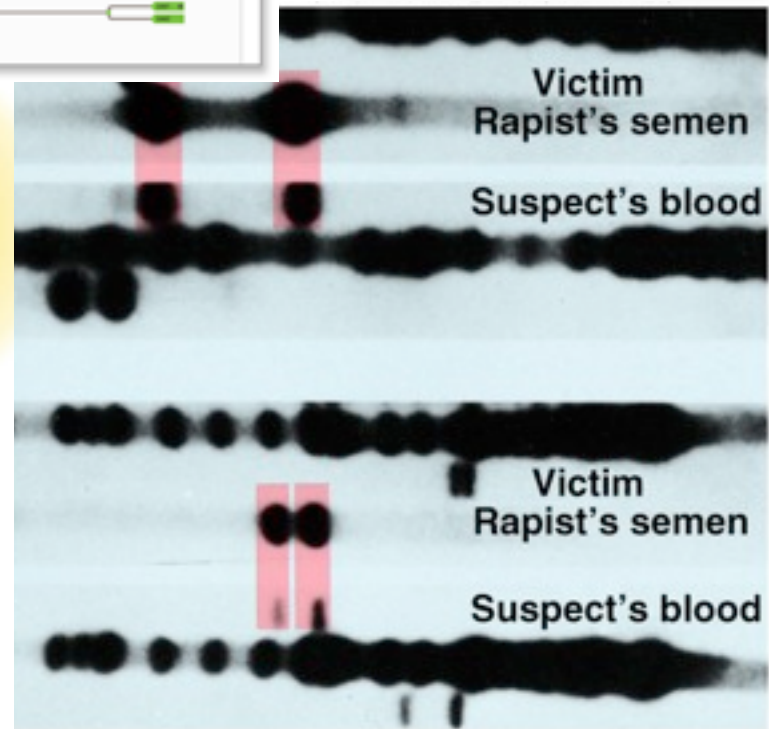
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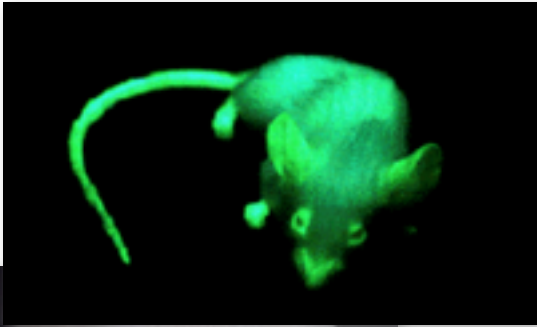
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The code is universal

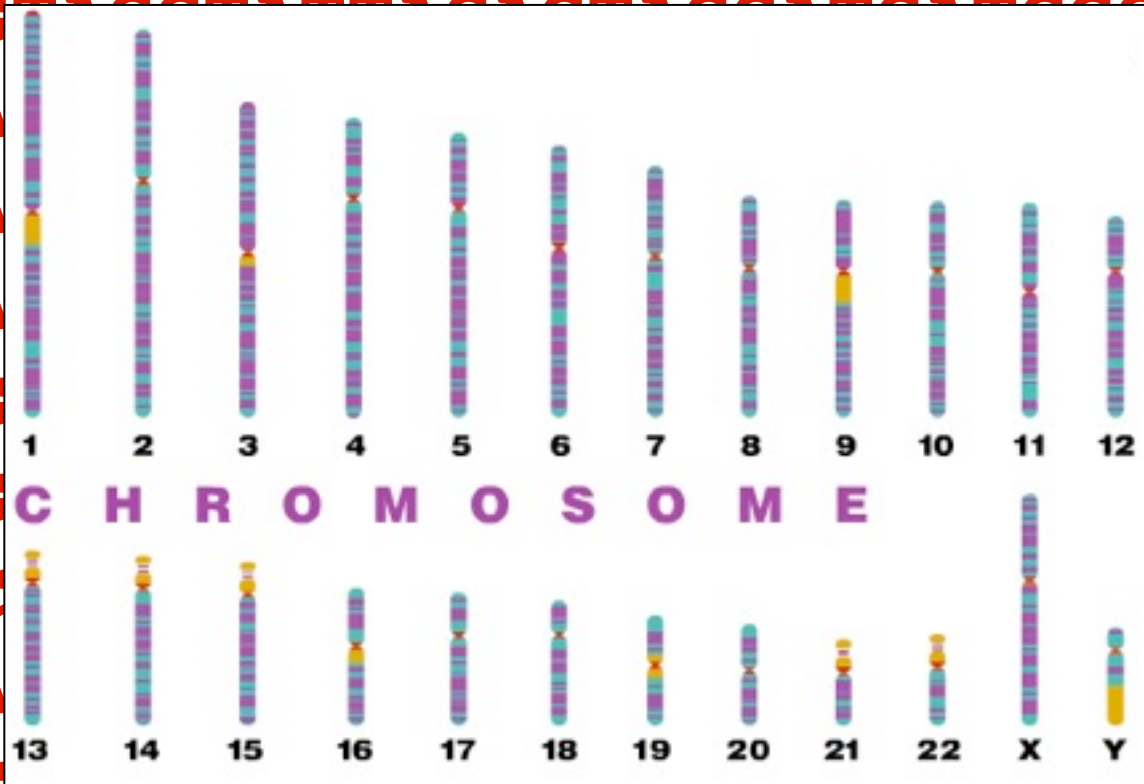
- Since all living organisms...
 - ◆ use the same DNA
 - ◆ use the same code book
 - ◆ read their genes the same way

		Second base				
		U	C	A	G	
U	UUU	UCU	UAU	UGU	U	
	UUC	UCC	UAC	UGC	C	
	UUA	UCA	UAA Stop	UGA Stop	A	
	UUG	UCG	UAG Stop	UGG Trp	G	
C	CUU	CCU	CAU	CGU	U	
	CUC	CCC	CAC	CGC	C	
	CUA	CCA	CAA	CGA	A	
	CUG	CCG	CAG	CGG	G	
A	AUU	ACU	AAU	AGU	U	
	AUC	ACC	AAC	AGC	C	
	AUA	ACA	AAA	AGA	A	
	AUG Met or start	ACG	AAG	AGG	G	
G	GUU	GCU	GAU	GGU	U	
	GUC	GCC	GAC	GGC	C	
	GUA	GCA	GAA	GGA	A	
	GUG	GCG	GAG	GGG	G	

**TACGCACATTTACGTACGCGGATGCCGCGACTATGATC
ACATAGACATGCTGTCAGCTCTAGTAGACTAGCTGACT
CGACTAGCATGATCGATCAGCTACATGCTAGCACACYC
GTACATCGATCCTGACATCGACCTGCTCGTACATGCTA
CTAGCTACTGACTCATGATCCAGATCACTGAAACCCTA
GATCGGGTACCTATTACAGTACGATCATCCGATCAGAT
CATGCTAGTACATCGATCGATACTGCTACTGATCTAGC
TCAATCAAACCTTTTTTGCATCATGATACTAGACTAGC
TGACTGATCATGACTCTGATCCCGTAGATCGGGTACCT
ATTACAGTACGATCATCCGATCAGATCATGCTAGTACA
TCGATCGATACTGCTACTGATCTAGCTCAATCAAACCTC
TTTTTGCATCATGATACTAGACTAGCTGACTGATCATG
ACTCTGATCCCGTAGATCGGGTACCTATTACAGTACGA
TCATCCGATCAGATCATGCTAGTACATCGATCGATACT**

human genome

3.2 billion bases

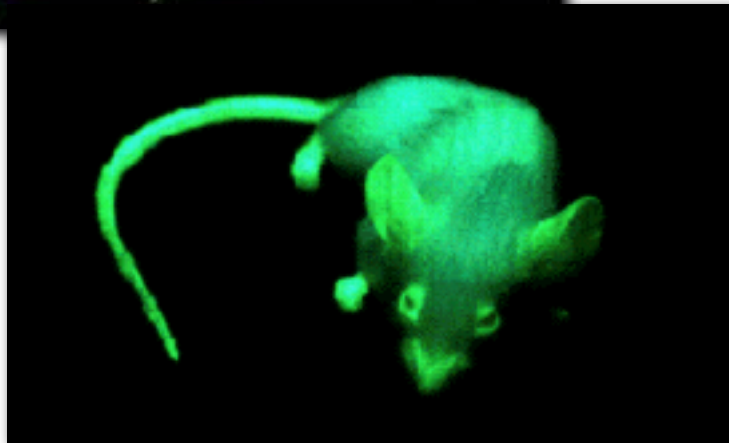


Can we mix genes from one creature to another?

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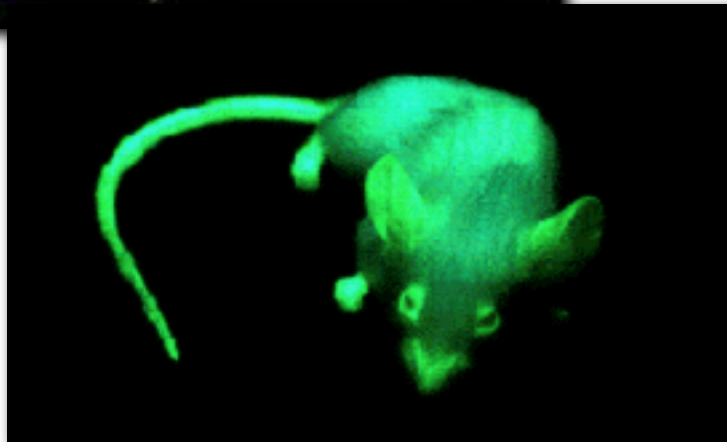


Can we mix genes from one creature to another?



Regents Biology

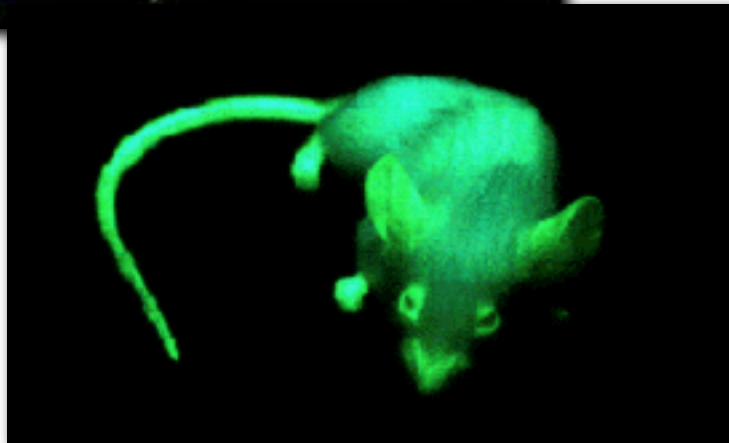
Can we mix genes from one creature to another?



Regents Biology

Can we mix genes from one creature to another?

YES!



Mixing genes for medicine...

Humulin[®]



Regents Biology

Mixing genes for medicine...

- Allowing organisms to produce new proteins

Humulin[®]



Regents Biology

Mixing genes for medicine...

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 - ◆ bacteria producing human insulin

Humulin®



Regents Biology

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 - ◆ bacteria producing human growth hormone

Humulin®



Regents Biology

How do we do mix genes?



How do we do mix genes?

- Genetic engineering



How do we do mix genes?

- **Genetic engineering**
 - ◆ find gene



How do we do mix genes?

- Genetic engineering
 - ◆ find gene
 - ◆ cut DNA in both organisms



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- ◆ **cut** DNA in both organisms
- ◆ **paste** gene from one creature into other creature's DNA



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- ◆ insert new chromosome into organism
- ◆ organism copies new gene as if it were its own
- ◆ organism reads gene as if it were its own
- ◆ organism produces NEW protein:
Remember: we all use the same genetic code!



Cutting DNA



GTAACGAATTCACGCTT
CATTGCTTAAGTGCGAA

Cutting DNA

- DNA “scissors”



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 - ◆ enzymes that cut DNA



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Restriction enzymes



Restriction enzymes

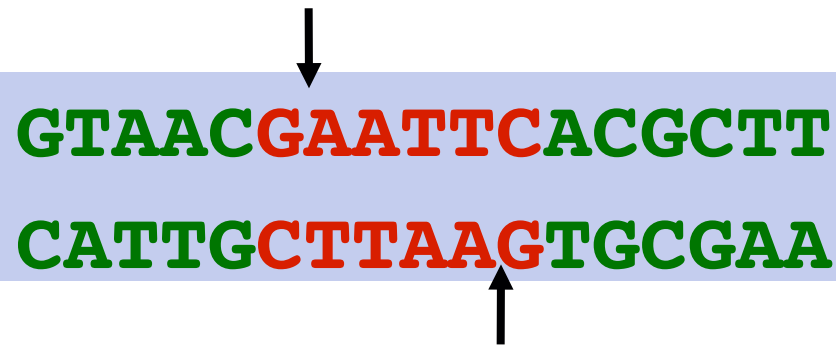
- **Cut DNA at specific sites**

Restriction enzymes

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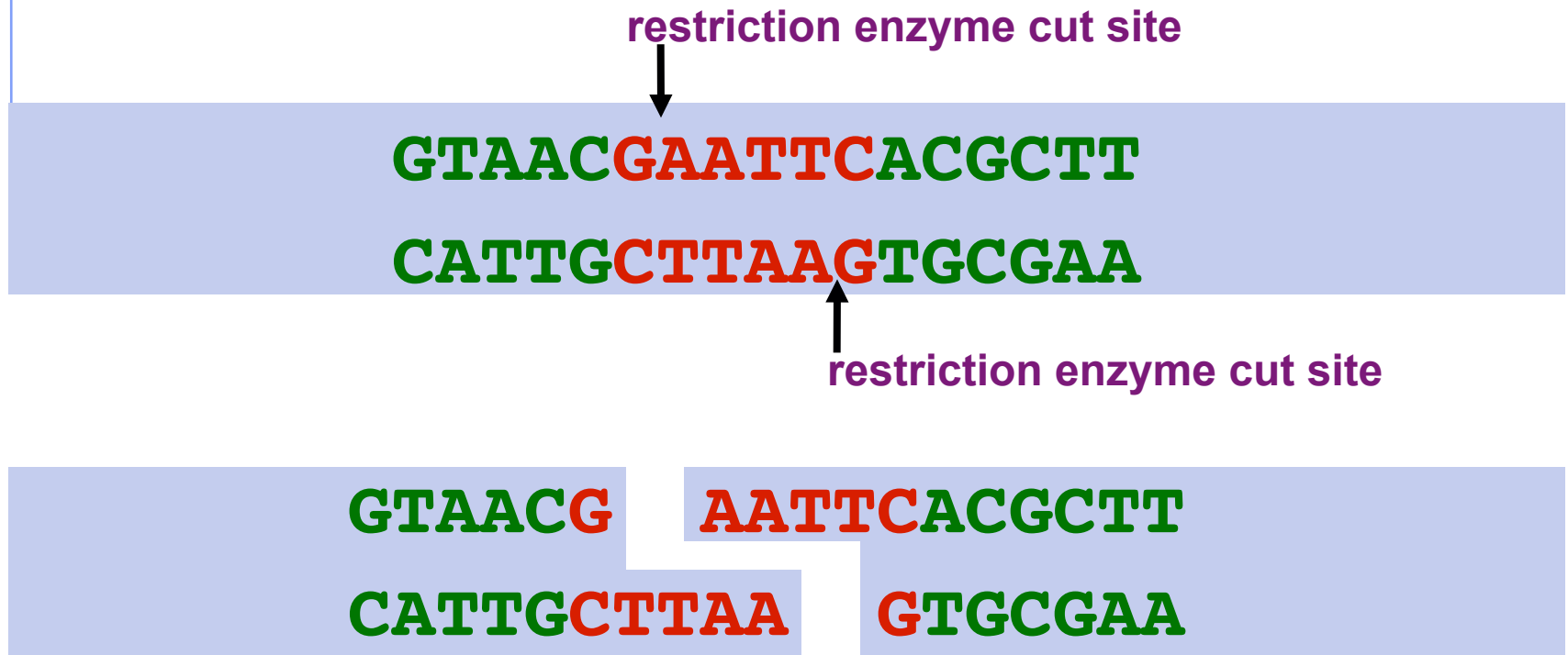
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Sticky ends



Sticky ends

- **Cut other DNA with same enzymes**

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gene
you want

Sticky ends

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GTAACG **AATTCACGCTT**
CATTGCTTAA **GTGCGAA**

gene
you want

GGACCTG **AATTC CGGATA**
CCTGGACTTAA **GGCCTAT**

chromosome
want to add
gene to

Sticky ends

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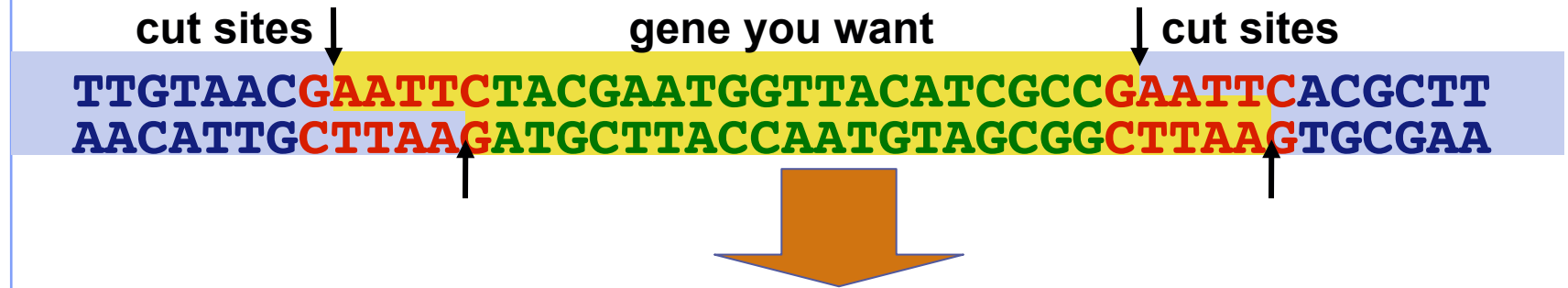
GGACCTG **AATTC CGGATA**
CCTGGACTTAA **GGCCTAT**

chromosome
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GGACCTG **AATTCACGCTT**
CCTGGACTTAA **GTGCGAA**

combined
DNA

Sticky ends help glue genes together



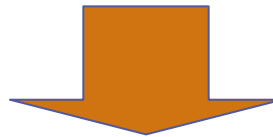
Sticky ends help glue genes together

cut sites ↓ gene you want ↓ cut sites

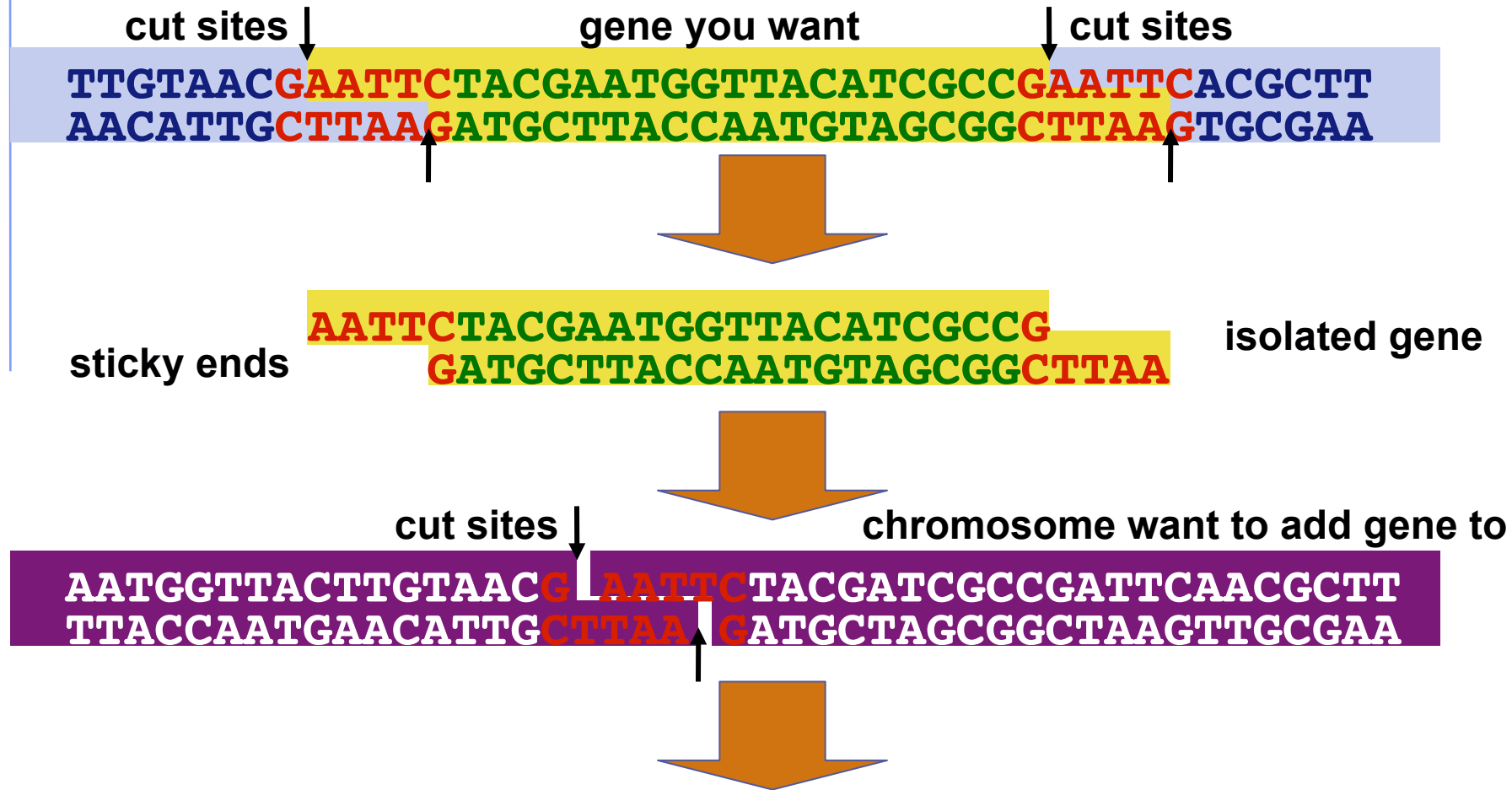
TTGTAACGAATTCCTACGAATGGTTACATCGCCGAATTCACGCTT
AACATTGCTTAAGATGCTTACCAATGTAGCGGCTTAAGTGCGAA



sticky ends AATTCCTACGAATGGTTACATCGCCG isolated gene
GATGCTTACCAATGTAGCGGCTTAA



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AACATTGCTTAAGATGCTTACCAATGTAGCGGCTTAAGTGCGAA

sticky ends

AATTCACGCTT
GATGCTTACCAATGTAGCGGCTTAAG

isolated gene

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AATGGTACTTGTAACGAATTCACGCTT
TTACCAATGAACATTGCTTAAGATGCTAGCGGCTAAGTTGCGAA

DNA ligase joins the strands

sticky ends stick together

chromosome with new gene added

Re

TAACGAATTCACGCTT
CATTGCTTAAGATGCTTACCAATGTAGCGGCTTAAGATGCTAGC

Sticky ends help glue genes together

cut sites ↓ gene you want ↓ cut sites

TTGTAAC **GAATTC** TACGAATGGTTACATCGCC **GAATTC** CACGCTT
 AACATTG **CTTAAG** ATGCTTACCAATGTAGCGG **CTTAAG** TGCGAA

sticky ends

AATTCTACGAATGGTTACATCGCC**G**
GATGCTTACCAATGTAGCGGCTTAA

isolated gene

cut sites ↓ chromosome want to add gene to

AATGGTACTTGTAAC**G** **AATTC**TACGATCGCCGATTCAACGCTT
 TTACCAATGAACATTG**CTTAA** **GATGCTAGCGGCTAAGTTGCGAA**

DNA **ligase** joins the strands

Recombinant DNA molecule

sticky ends stick together

chromosome with new gene added

Re **TAACGAATTC**TACGAATGGTTACATCGCC**GAATTC**TACGATC
CATTGCTTAAGATGCTTACCAATGTAGCGG**CTTAAG**ATGCTAGC

Why mix genes together?

- Gene produces protein in different organism or different individual

human insulin gene in bacteria

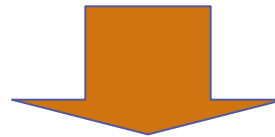
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“new” protein from organism

ex: human insulin from bacteria

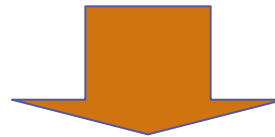


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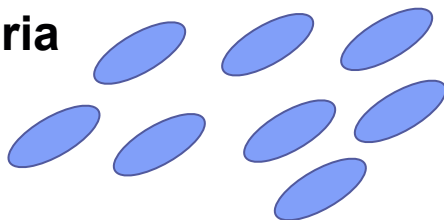


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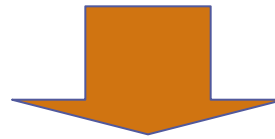


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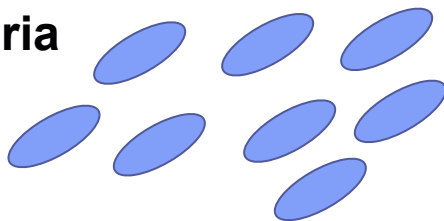


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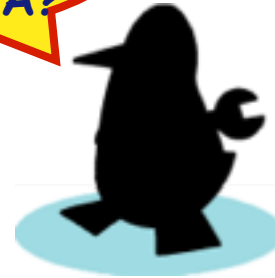
bacteria



human insulin

Why mix genes together?

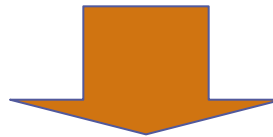
How can bacteria read human DNA?



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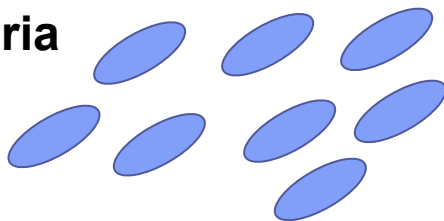


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human insulin

Uses of genetic engineering



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- Genetically modified organisms (GMO)



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- **Genetically modified organisms (GMO)**
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 - ◆ strawberries with an anti-freezing gene from flounder



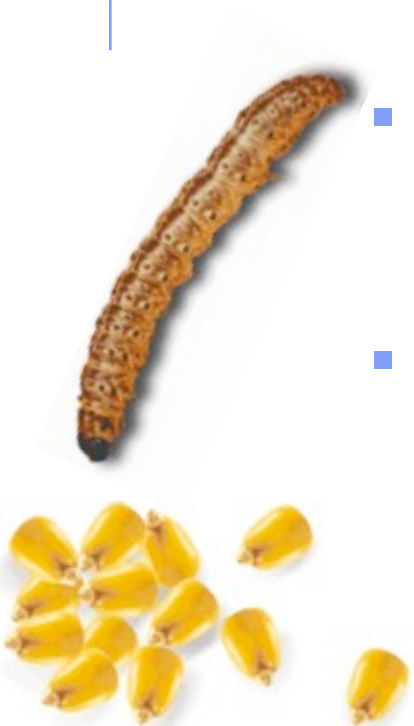
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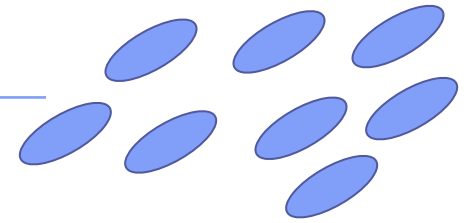


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 - Improve quality of food: **golden rice**
 - ◆ rice producing vitamin A improves nutritional value



Bacteria

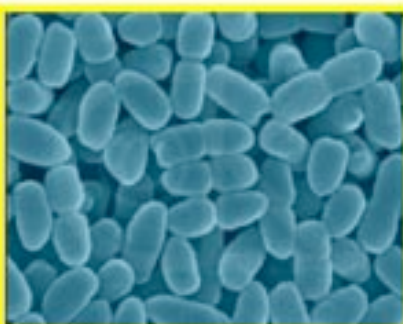


- **Bacteria are great!**
 - ◆ one-celled organisms
 - ◆ reproduce by mitosis
 - easy to grow, fast to grow
 - ◆ generation every ~20 minutes

Bacillus



Bordetella



Clostridium



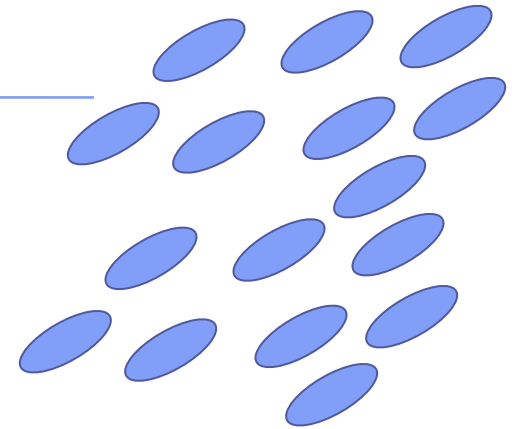
Escherichia



Re...

Bacteria

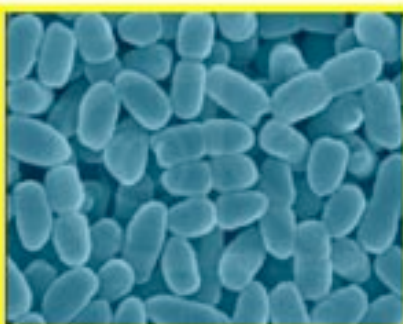
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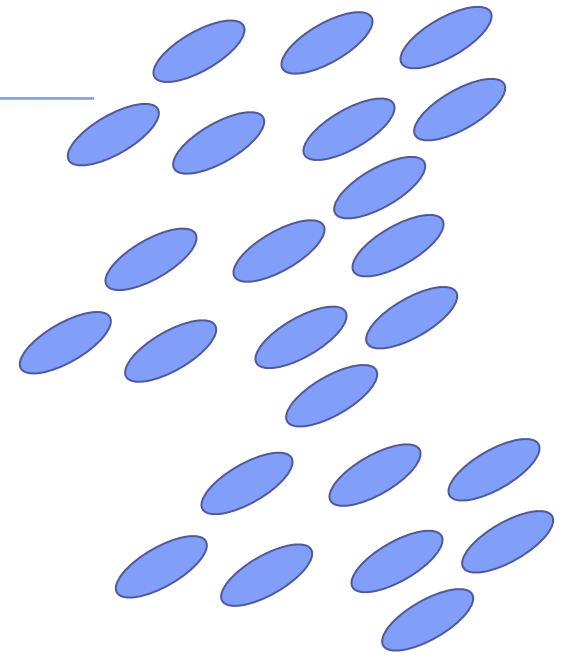
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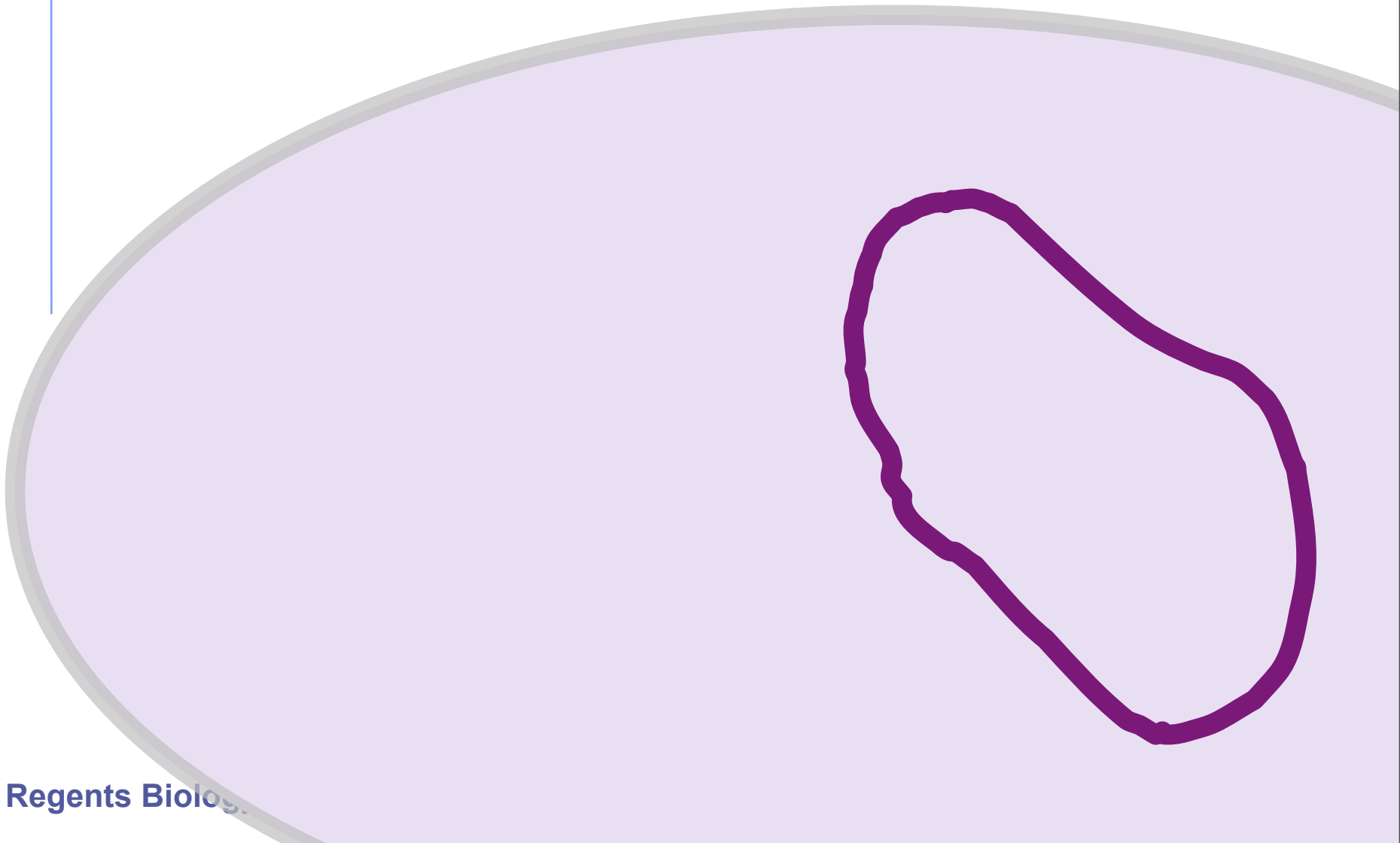
Clostridium

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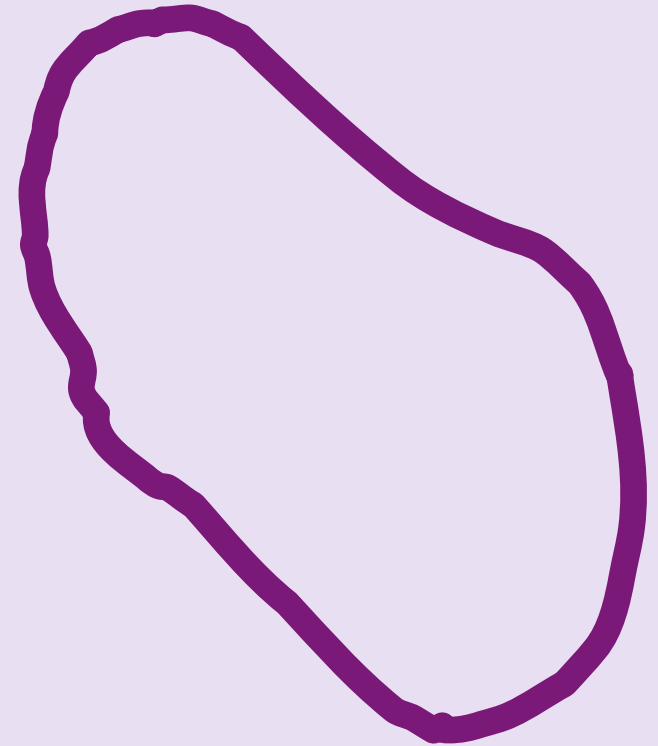
Re...

Bacterial DNA



Bacterial DNA

- **Single circular chromosome**
 - ◆ only one copy = haploid
 - ◆ no nucleus



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- **Other DNA = plasmids!**

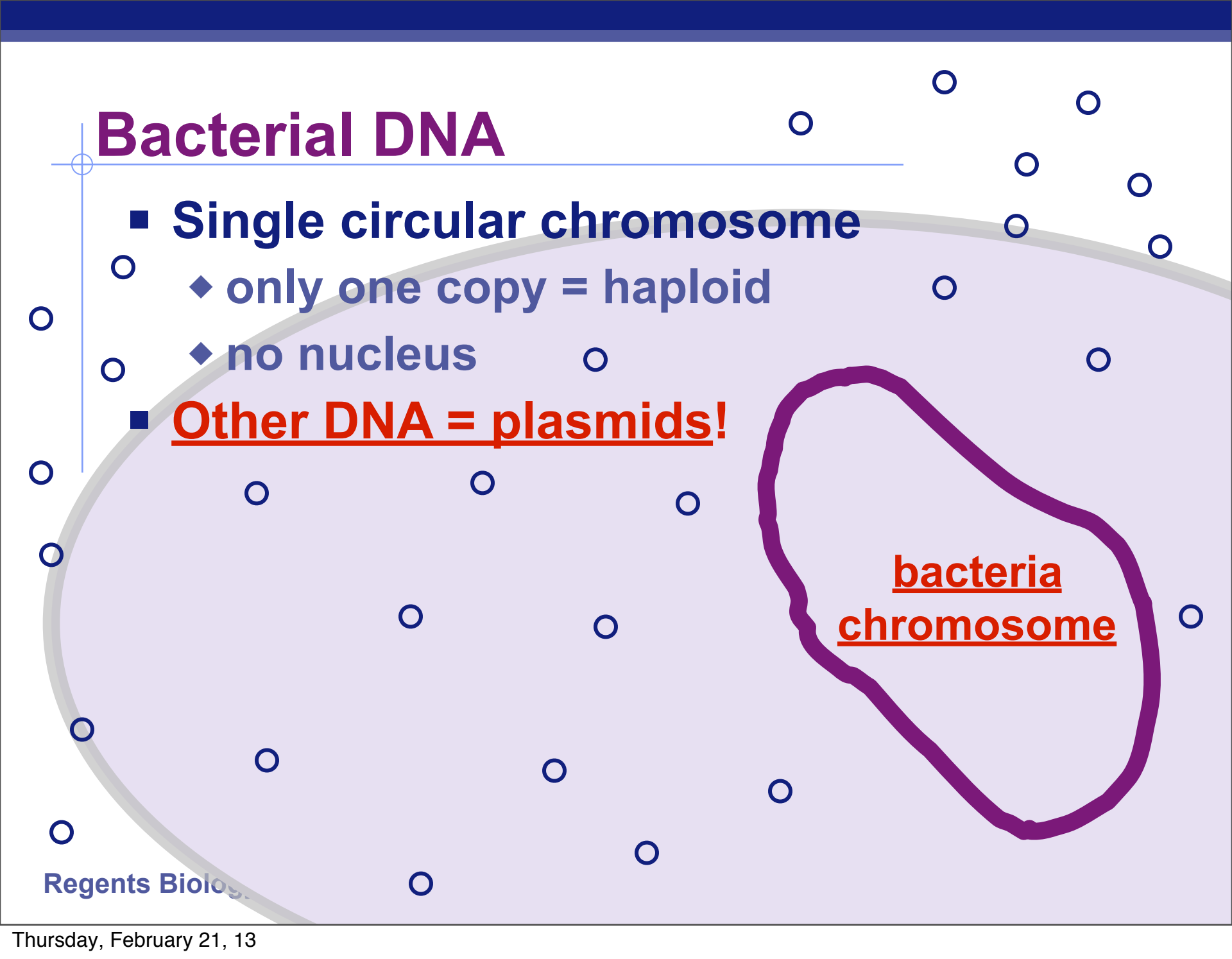
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bacteria
chromosome

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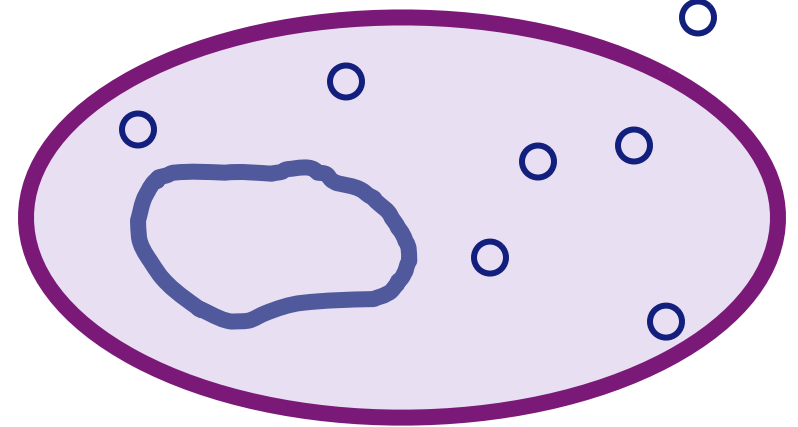
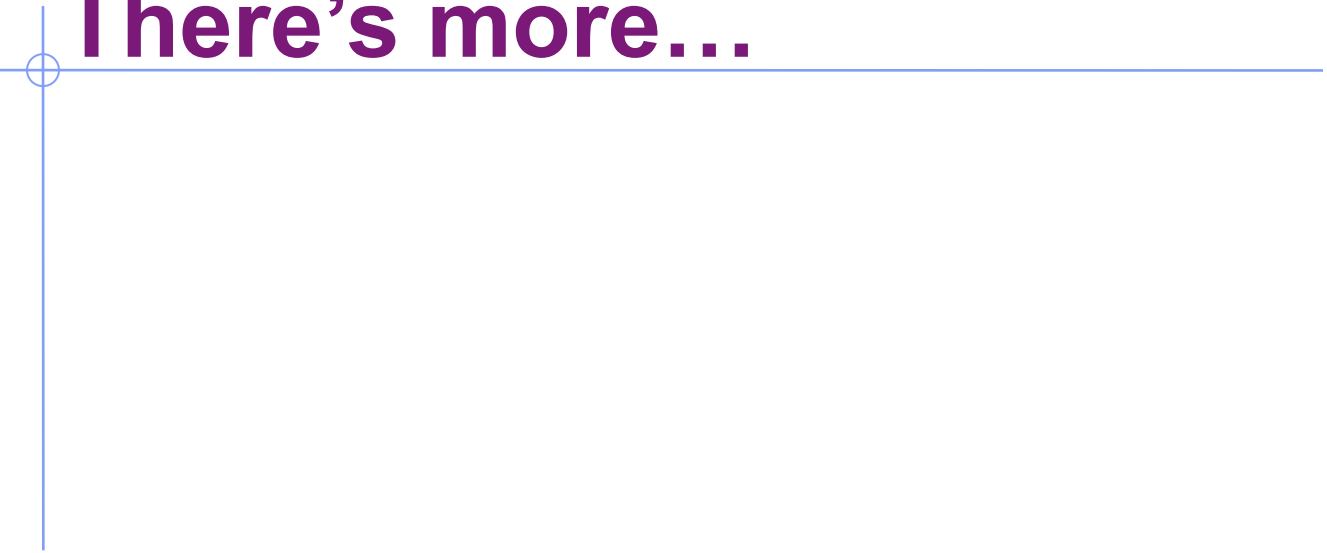
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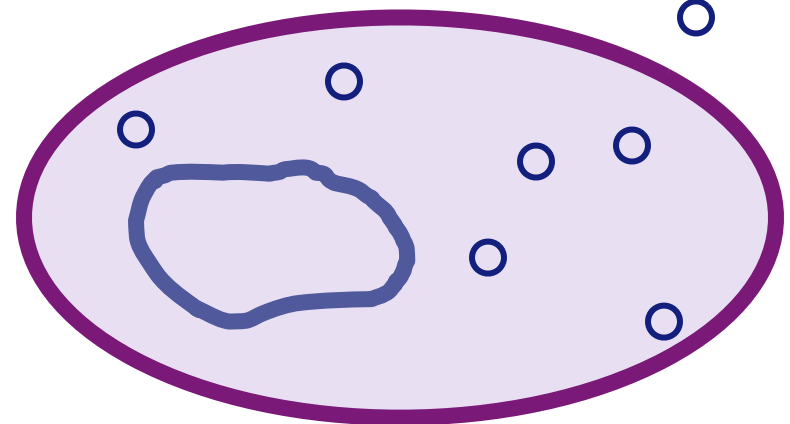
plasmids

There's more...



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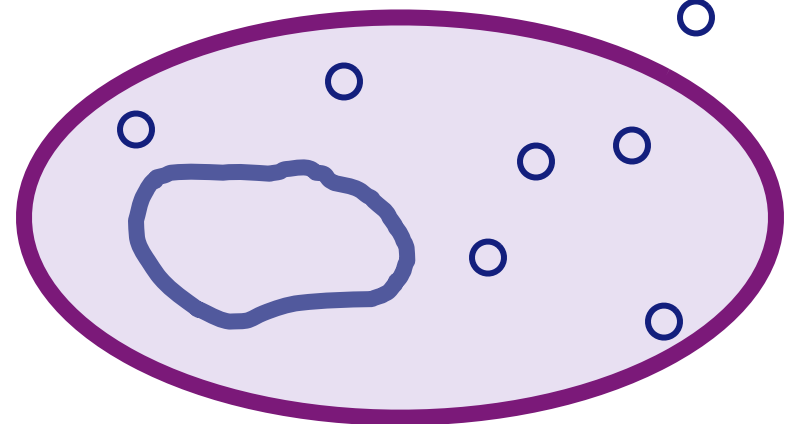
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There's more...

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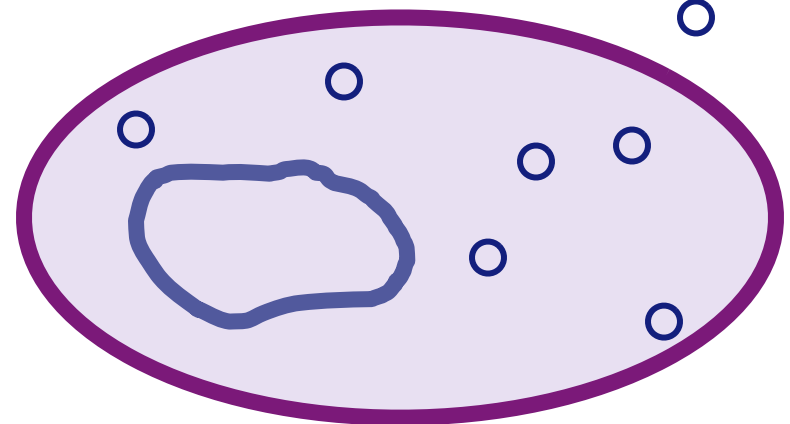
- ◆ small extra circles of DNA



There's more...

- **Plasmids**

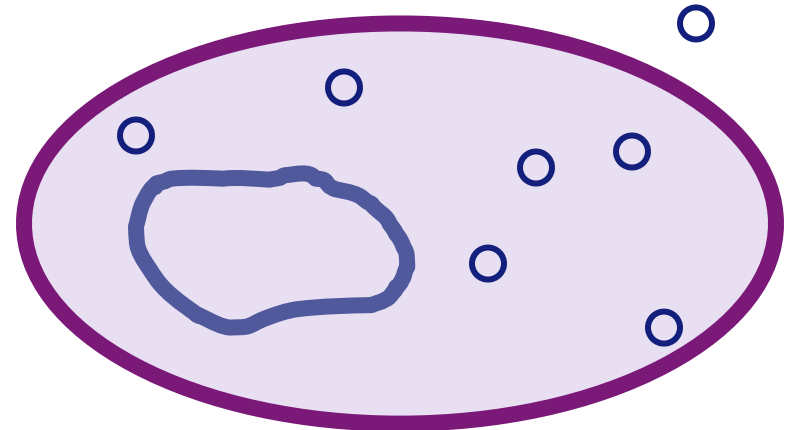
- ◆ small extra circles of DNA
- ◆ carry extra genes that bacteria can use



There's more...

■ Plasmids

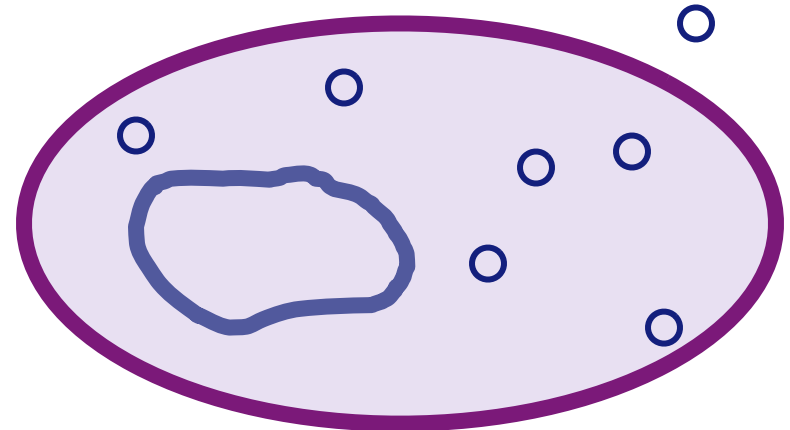
- ◆ small extra circles of DNA
- ◆ carry extra genes that bacteria can use
- ◆ can be swapped between bacteria



There's more...

■ Plasmids

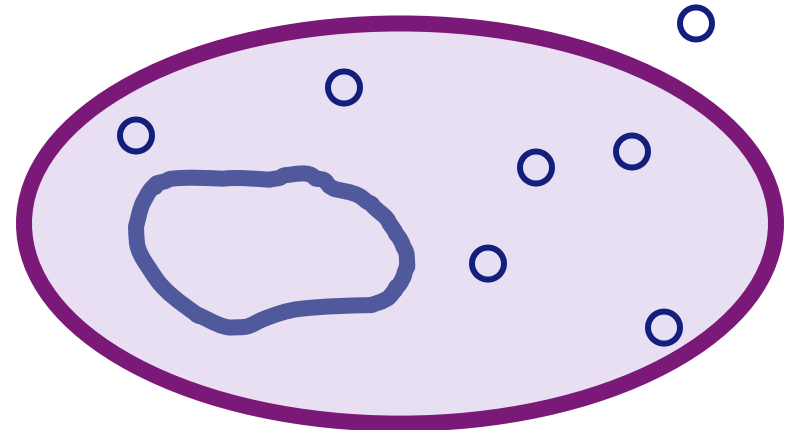
- ◆ small extra circles of DNA
- ◆ carry extra genes that bacteria can use
- ◆ can be swapped between bacteria
 - bacterial sex!!



There's more...

■ Plasmids

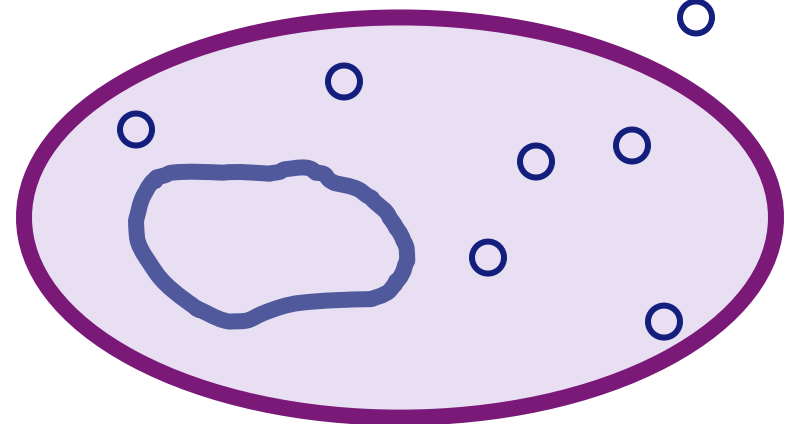
- ◆ small extra circles of DNA
- ◆ carry extra genes that bacteria can use
- ◆ can be swapped between bacteria
 - bacterial sex!!
 - rapid evolution = antibiotic resistance



There's more...

■ Plasmids

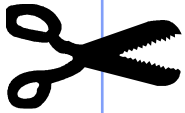
- ◆ small extra circles of DNA
- ◆ carry extra genes that bacteria can use
- ◆ can be swapped between bacteria
 - bacterial sex!!
 - rapid evolution = antibiotic resistance
- ◆ can be picked up from environment



Grow bacteria...make more



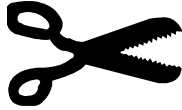
Grow bacteria...make more



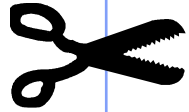
plasmid

Grow bacteria...make more

gene from
other organism

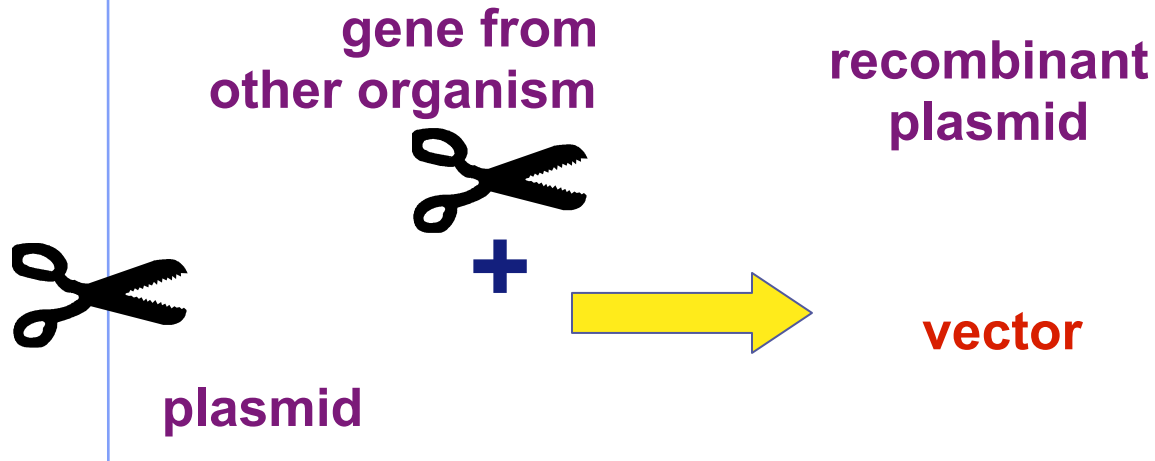


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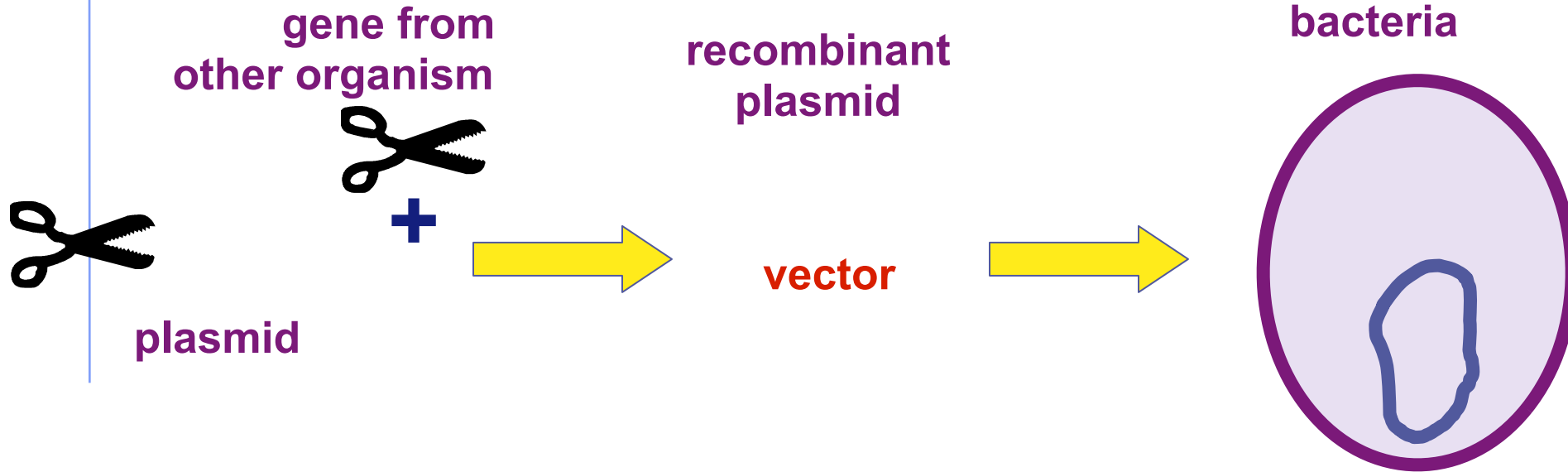


plasmid

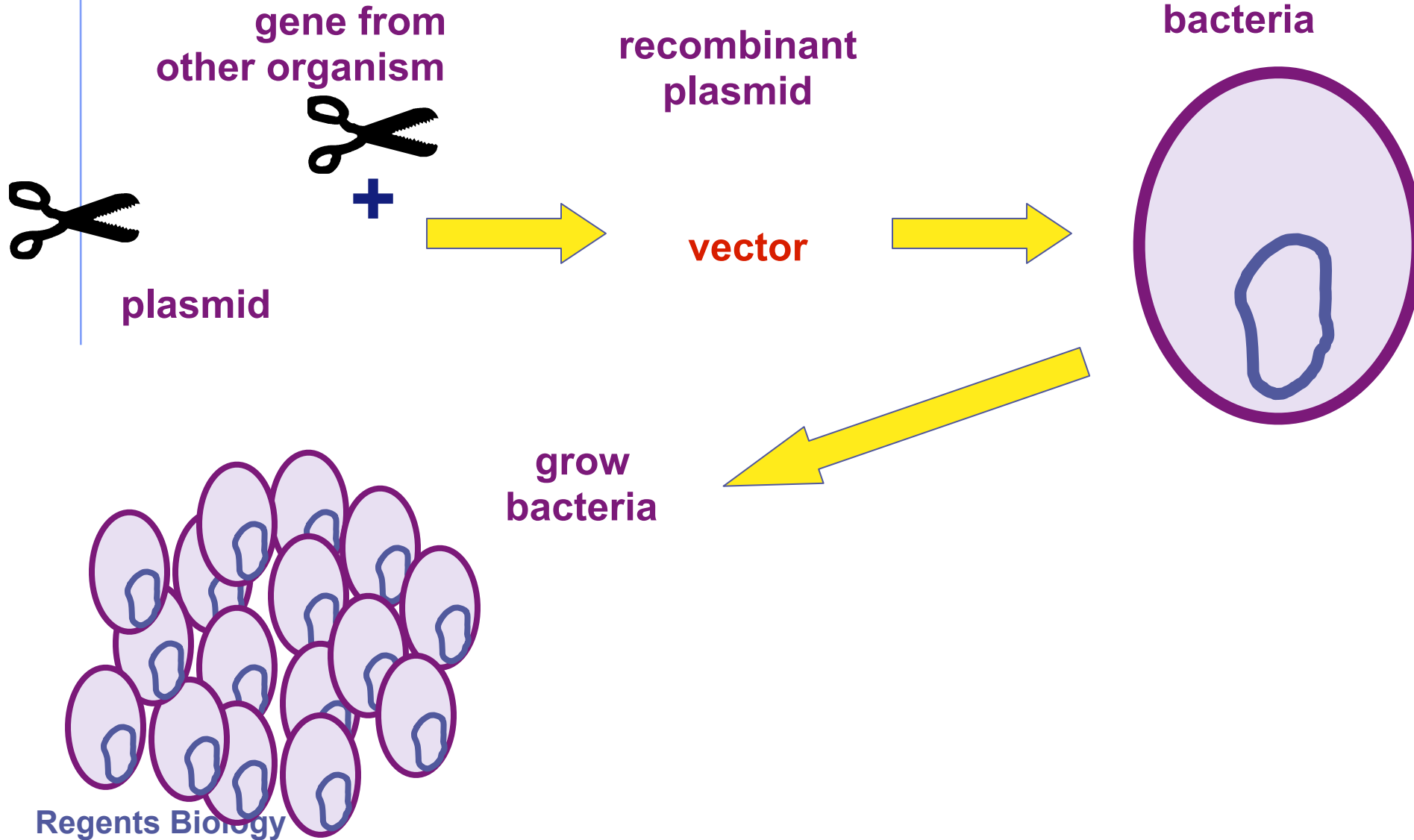
Grow bacteria...make more



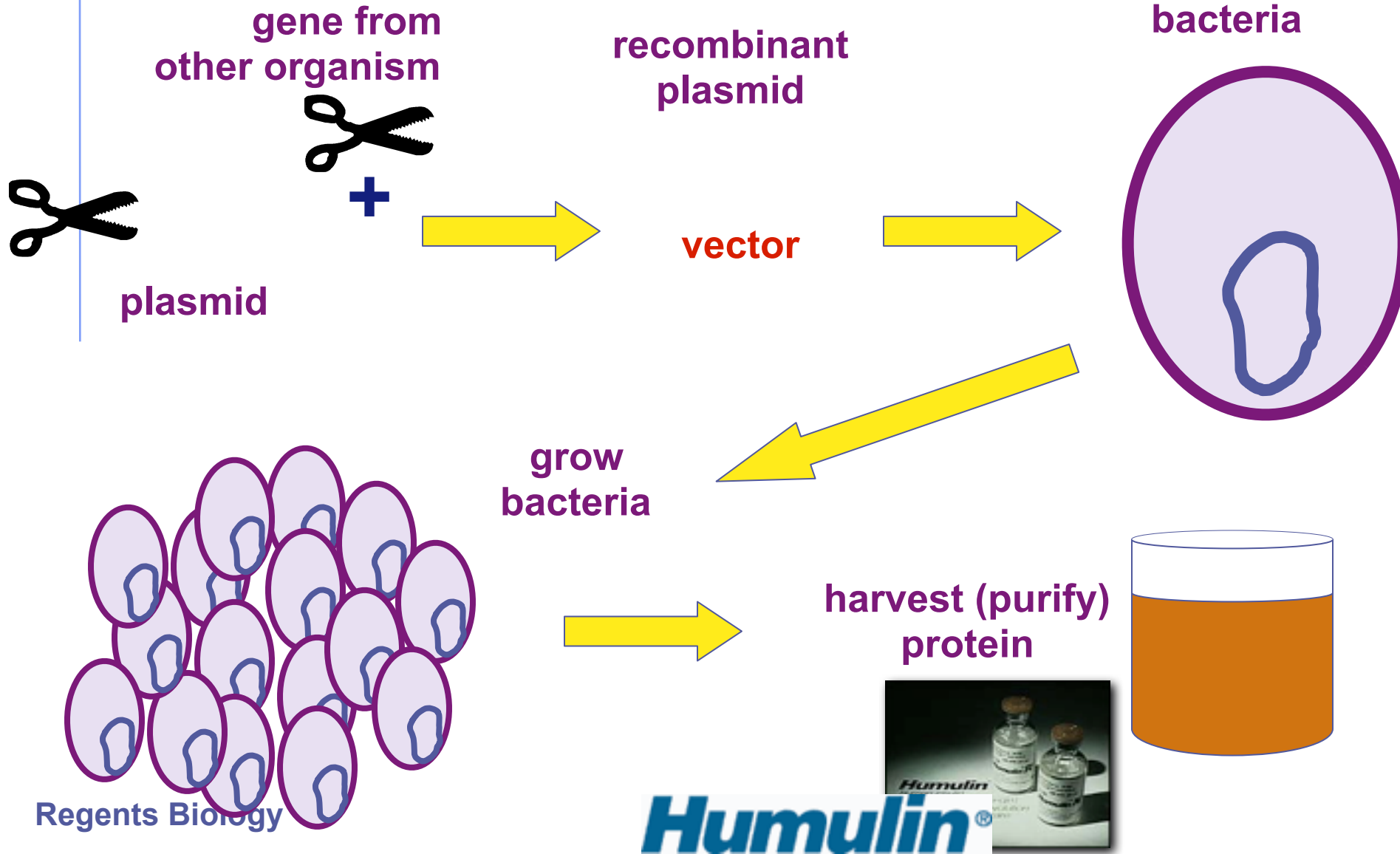
Grow bacteria...make more



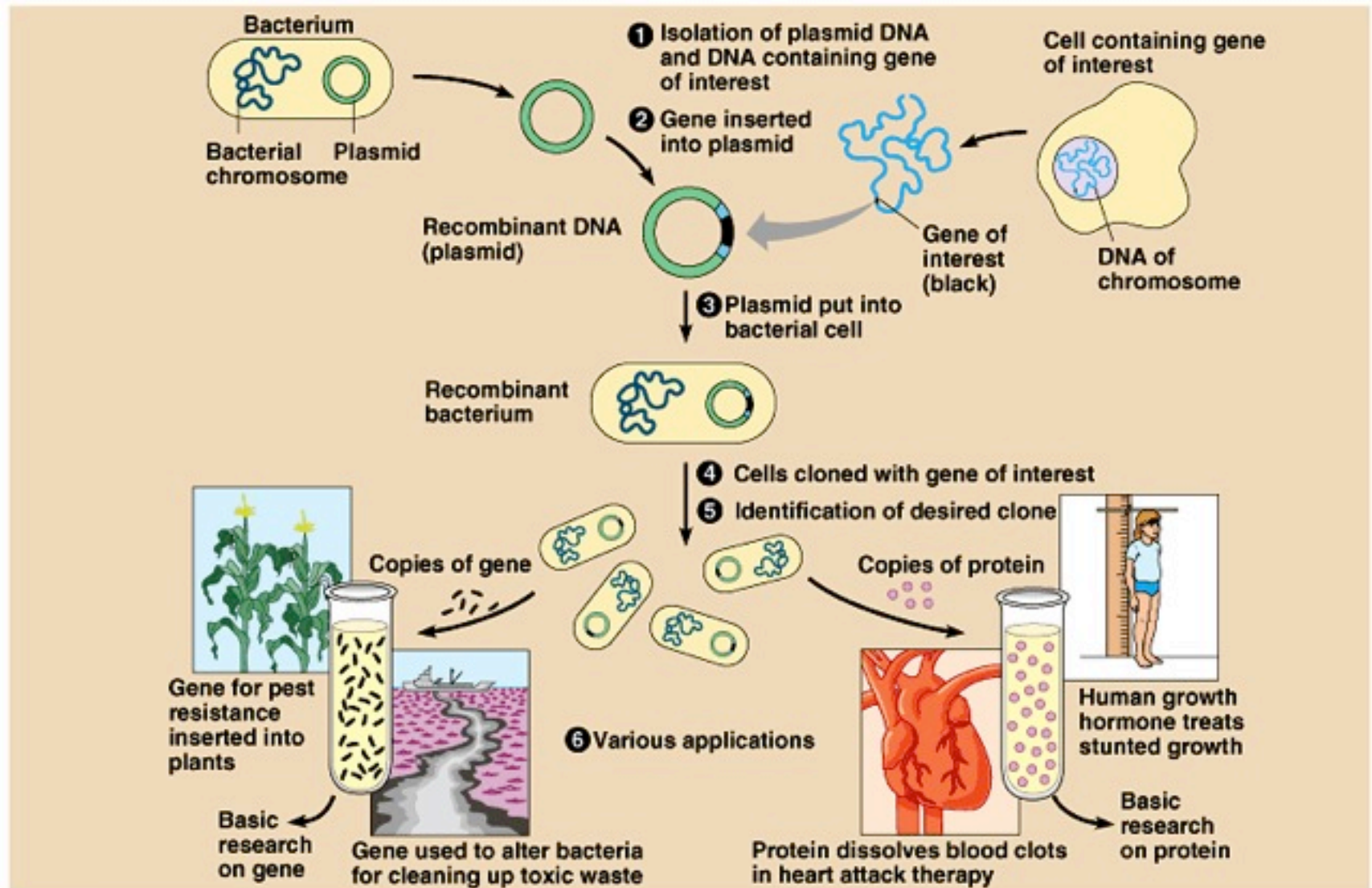
Grow bacteria...make more



Grow bacteria...make more



Applications of biotechnology



**I'm a very special pig!
Got any Questions?**

