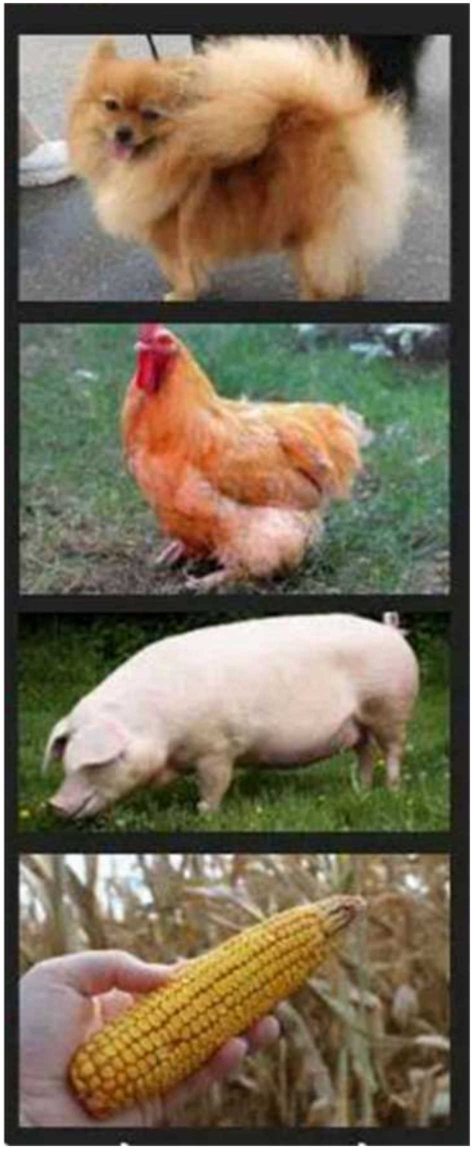
Melhoramento genético, organismos geneticamente modificados e transformação genética de plantas

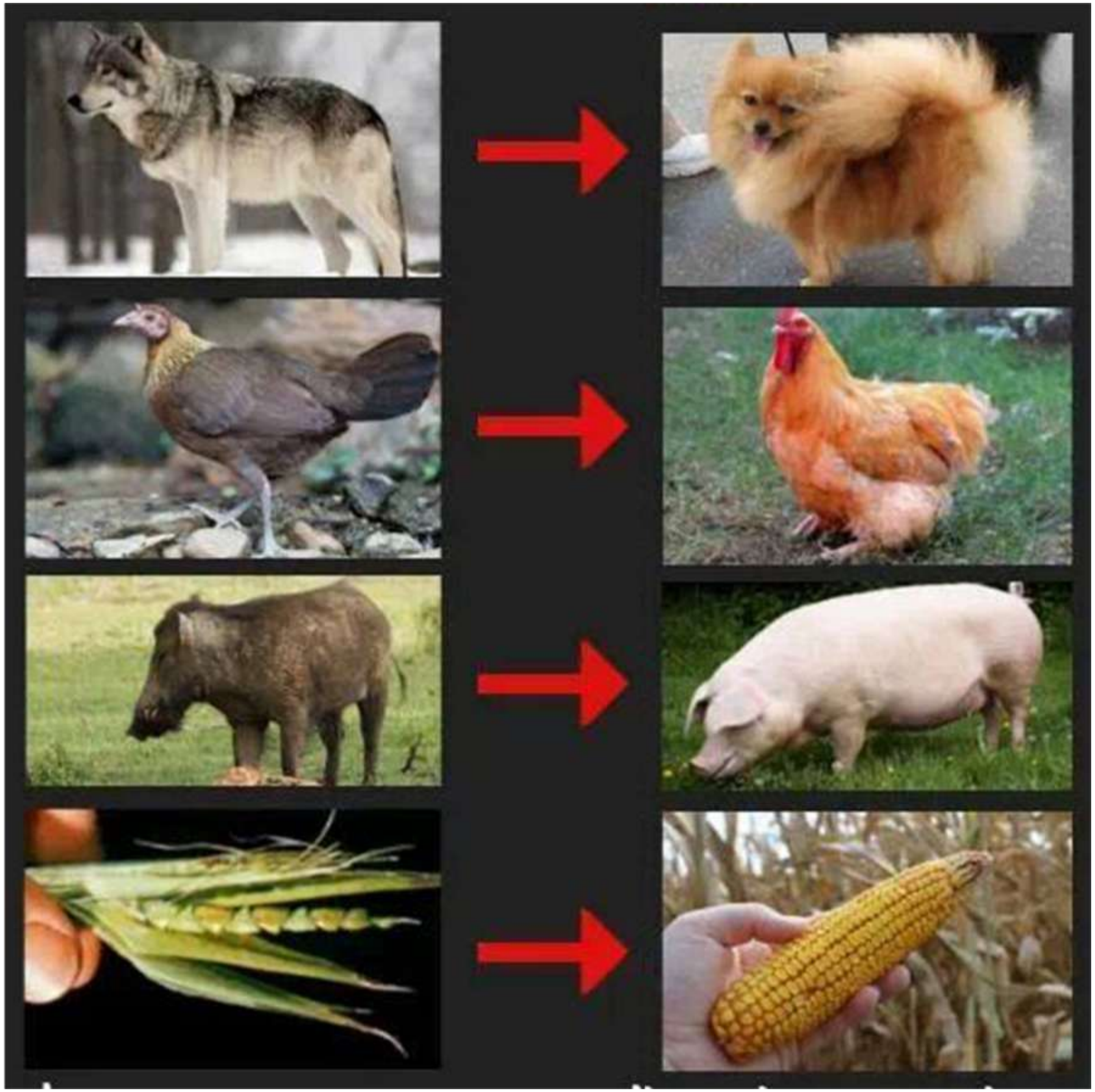
2023

BIB0143 - Recursos Econômicos Vegetais

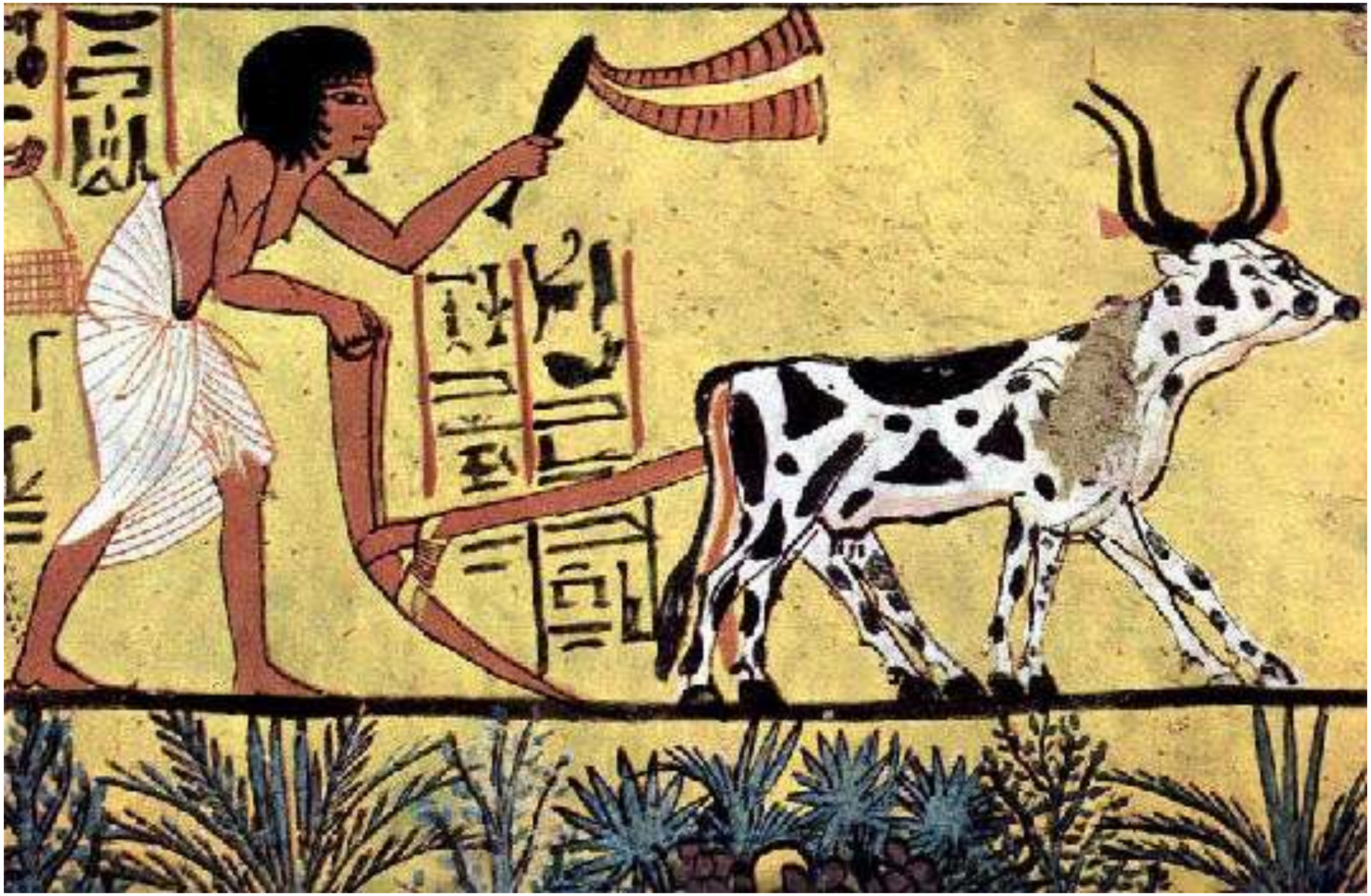
Magdalena Rossi



Domesticação/Melhoramento vs OGMs



Revolução neolítica (10,000 anos)
Domesticação e melhoramento de espécies de plantas e animais: surgem os OGMs



Domesticação vs OGMs

AKSENOVA NATALYA/SHUTTERSTOCK

VIKTAR MALYSHCHYTS/SHUTTERSTOCK

MAKS NARODENKO/SHUTTERSTOCK

Tabela 1.1 Domesticação de algumas espécies de animais e de plantas

Espécie domesticada	Espécie ancestral	Época da domesticação (anos atrás)	Local
Ovelha	Ovelha selvagem (*Ovis ammon*)	12.000	Iraque
Cão	Lobo (*Canis lupus*)	12.000	Palestina-Irã
Cabra	Cabra selvagem (*Capra aegagrus*)	10.000	Irã
Gato	Gato selvagem (*Felis caffra*)	9.500	Chipre ou Egito
Porco	Porco selvagem europeu (*Sus scrofa*)	10.000	Europa-Ásia
Cavalo	Cavalo selvagem (*Equus przevalski*)	8.000	Irã
Marreco	Marreco selvagem comum (*Anas platyrhynchus*)	6.000	China
Camelo	Camelo selvagem (*Camelus bactrianus*)	6.000-5.000	Egito
Jumento	Jumento selvagem (*Equus asinus atlanticus*)	7.000	Egito
Abelha	Abelha (*Apis mellifera*)	4.500	Egito
Bicho-da-seda	Bicho-da-seda (*Bombyx mori*)	3.500	China
Coelho	Coelho selvagem (*Oryctolagus cuniculus*)	2.200	Roma
Arroz	Arroz selvagem asiático (*Oryza sativa*)	15.900	China central
Abóbora	Abóbora (*Cucurbita pepo*)	12.000-10.000	Equador
Trigo	Trigo selvagem (*Triticum monococcum*)	9.800-9.500	Turquia
Milho	Milho selvagem (*Zea mays*)	8.000-7.000	América
Linho	Linho selvagem (*Linum usitatissimum*)	7.000	Curdistão
Lentilha	Lentilha selvagem (*Lens culinaris*)	6.000	Egito
Azeitona	Azeitona (*Olea europaea*)	6.000	Oriente Médio
Feijão	Feijão (*Phaseolus* spp.)	5.000-4.000	Américas Central e do Sul
Soja	Soja (*Glycine max*)	4.000	China

Fonte: <http://www.clt.astate.edu/aromero/histbio04.heredityIprmendel.ppt>. Acesso em: abr. 2010.

O que é um OGM (organismo geneticamente modificados)?

Então todas as plantas que cultivamos e animais que criamos são OGMs.

Sim, porém....

O que é um OGM (organismo geneticamente modificados)?

"o organismo cujo material genético (DNA/RNA) tenha sido modificado por qualquer técnica de engenharia genética"

§1° - exclui organismo resultante de técnicas que impliquem a introdução direta, num organismo, de material hereditário, desde que não envolvam a utilização de moléculas de DNA/RNA recombinante ou OGM, tais como: fecundação *in vitro*, conjugação, transdução, transformação, indução poliplóide e qualquer outro processo natural

artigo 3º, inciso V, Lei Federal brasileira nº 11.105, de 24 de março de 2005

O que é um OGM (organismo geneticamente modificados)?

"Living modified organism" as any living organism that possesses a novel combination of genetic material obtained through the use of modern biotechnology (Cartagena Protocol on Biosafety, 2003)

application of in vitro nucleic acid techniques, or fusion of cells beyond the taxonomic family, that overcome natural physiological reproductive or recombination barriers and <u>are not techniques used in traditional breeding and selection</u>

Quando teve início o processo de **melhoramento genético** de espécies de interesse econômico?

Melhoramento com conhecimento de genética, relação um gene um caráter

~10.000

Atual

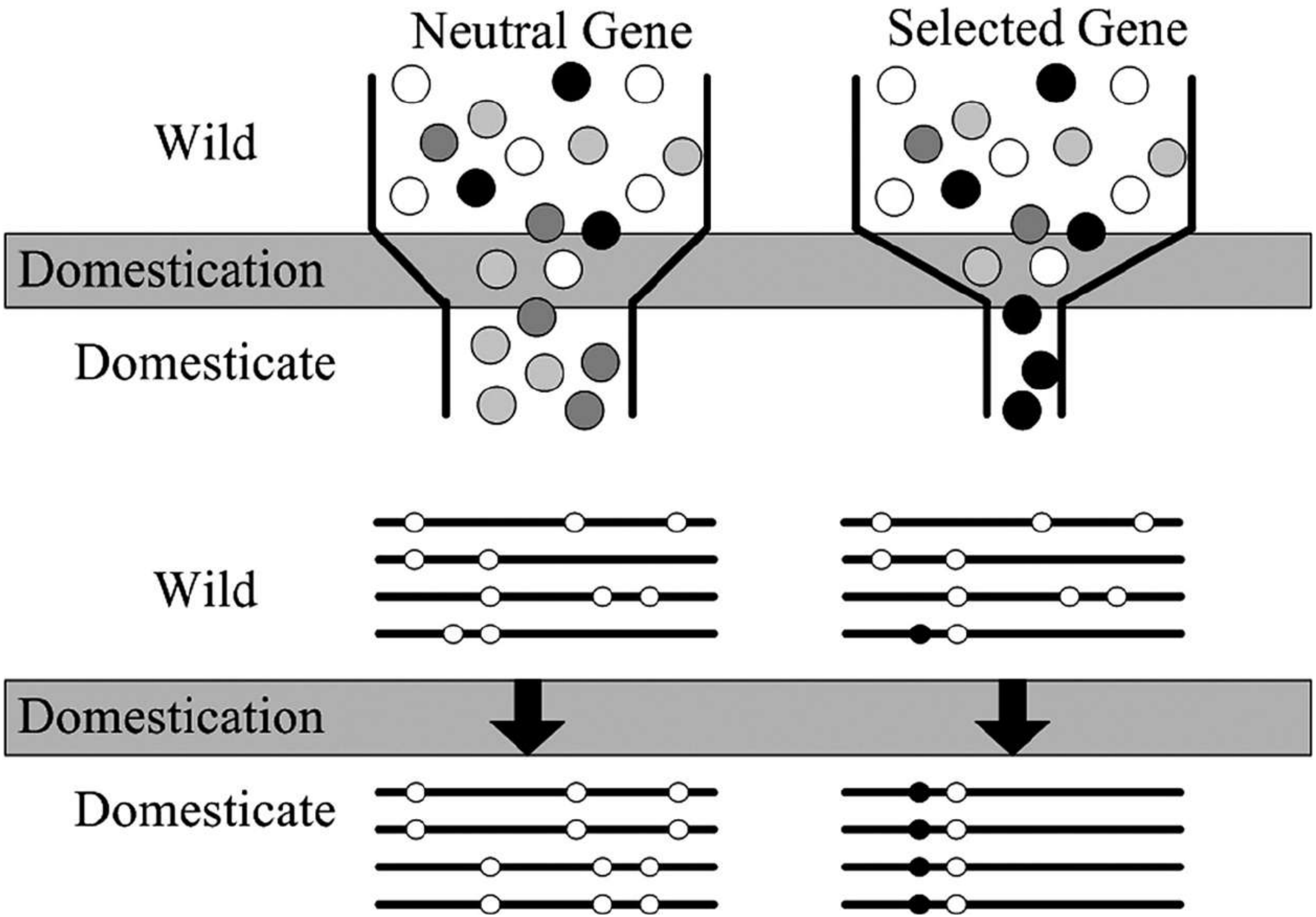
Seleção não intencional

Melhoramento sem conhecimento de genética, apenas selecionando características de interesse

Uso de biotecnologia e transgênicos

Fase científica do melhoramento: redescoberta dos estudos de Mendel

Gargalo de seleção: erosão gênica



Ross-Ibarra, J., Morrell, P. L., & Gaut, B. S. (2007). Plant domestication, a unique opportunity to identify the genetic basis of adaptation. Proceedings of the National Academy of Sciences, 104(suppl 1), 8641-8648.

LINHAGENS SELVAGENS:

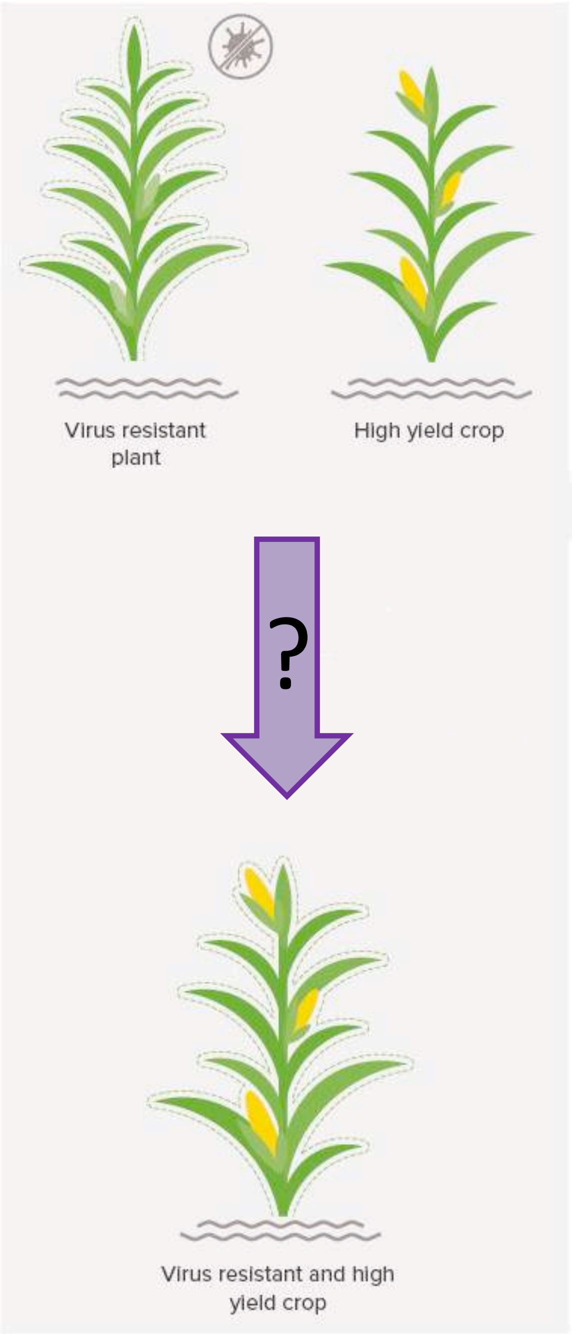
- ALTO GRAU DE HETEROZIGOSE
- BASE GENÉTICA AMPLA
- ELEVADO GRAU DE ADAPTABILIDADE

LINHAGENS MELHORADAS GENETICAMENTE:

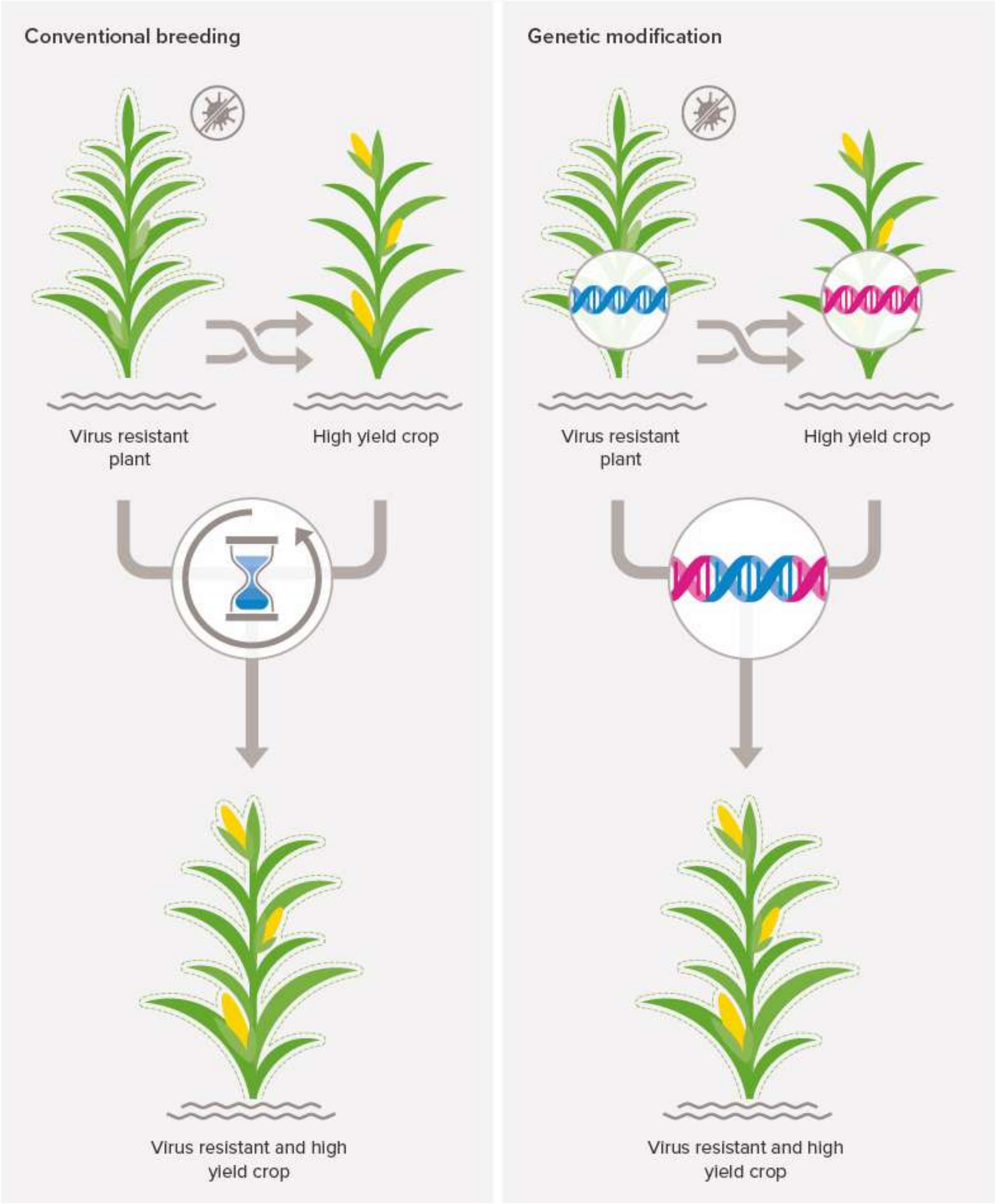
- ALTO GRAU DE HOMOZIGOSE
- BASE GENÉTICA ESTREITA
- BAIXO GRAU DE ADAPTABILIDADE

É muito importante preservar a variabilidade genética natural como "banco" de genes para melhoramento

Como introduzimos um determinado caráter numa variedade/espécie para obter uma variedade melhorada?



https://royalsociety.org/topics-policy/projects/gm-plants/how-does-gm-differ-from-conventional-plant-breeding/



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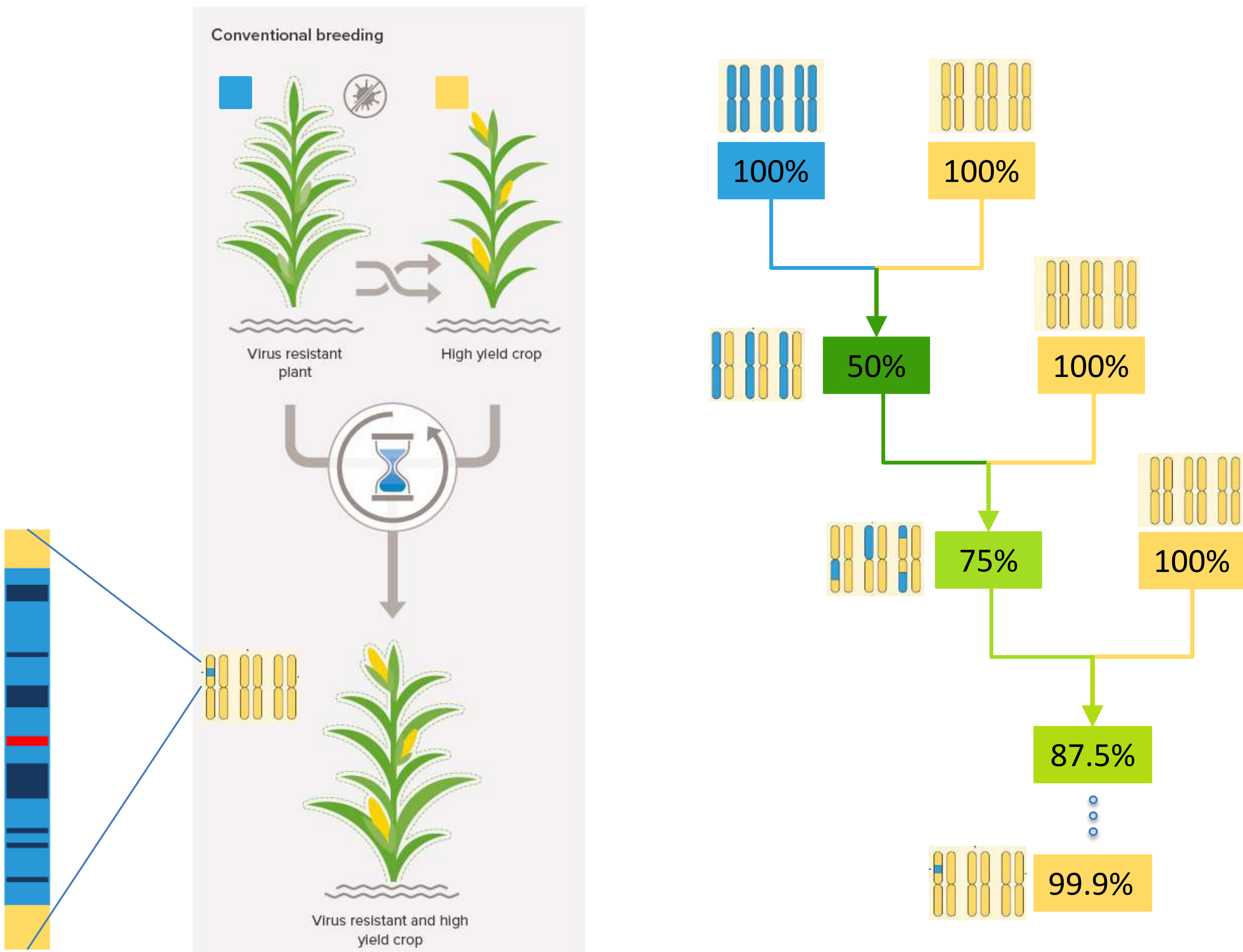
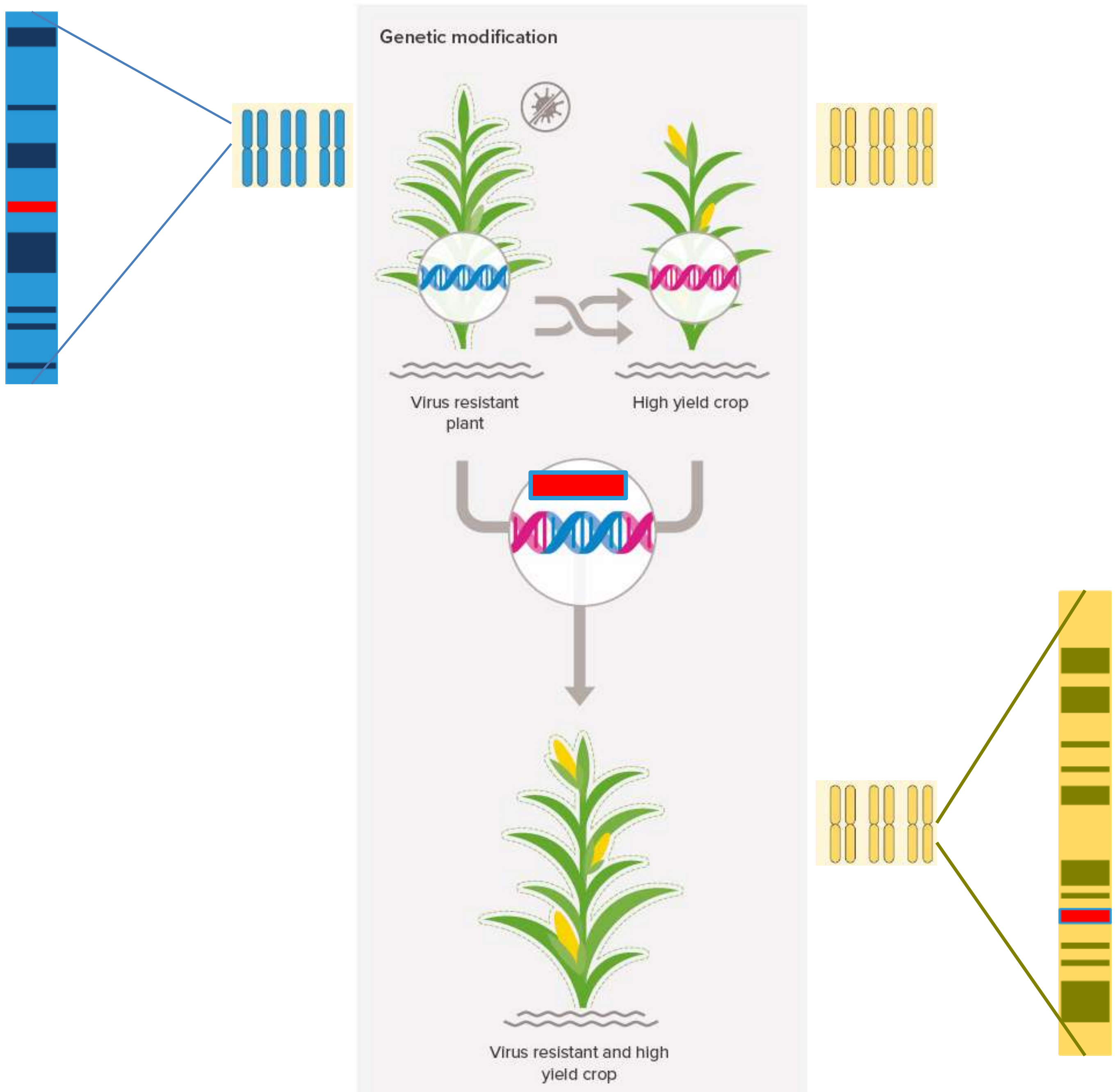


https://royalsociety.org/topics-policy/projects/gm-plants/how-does-gm-differ-from-conventional-plant-breeding/



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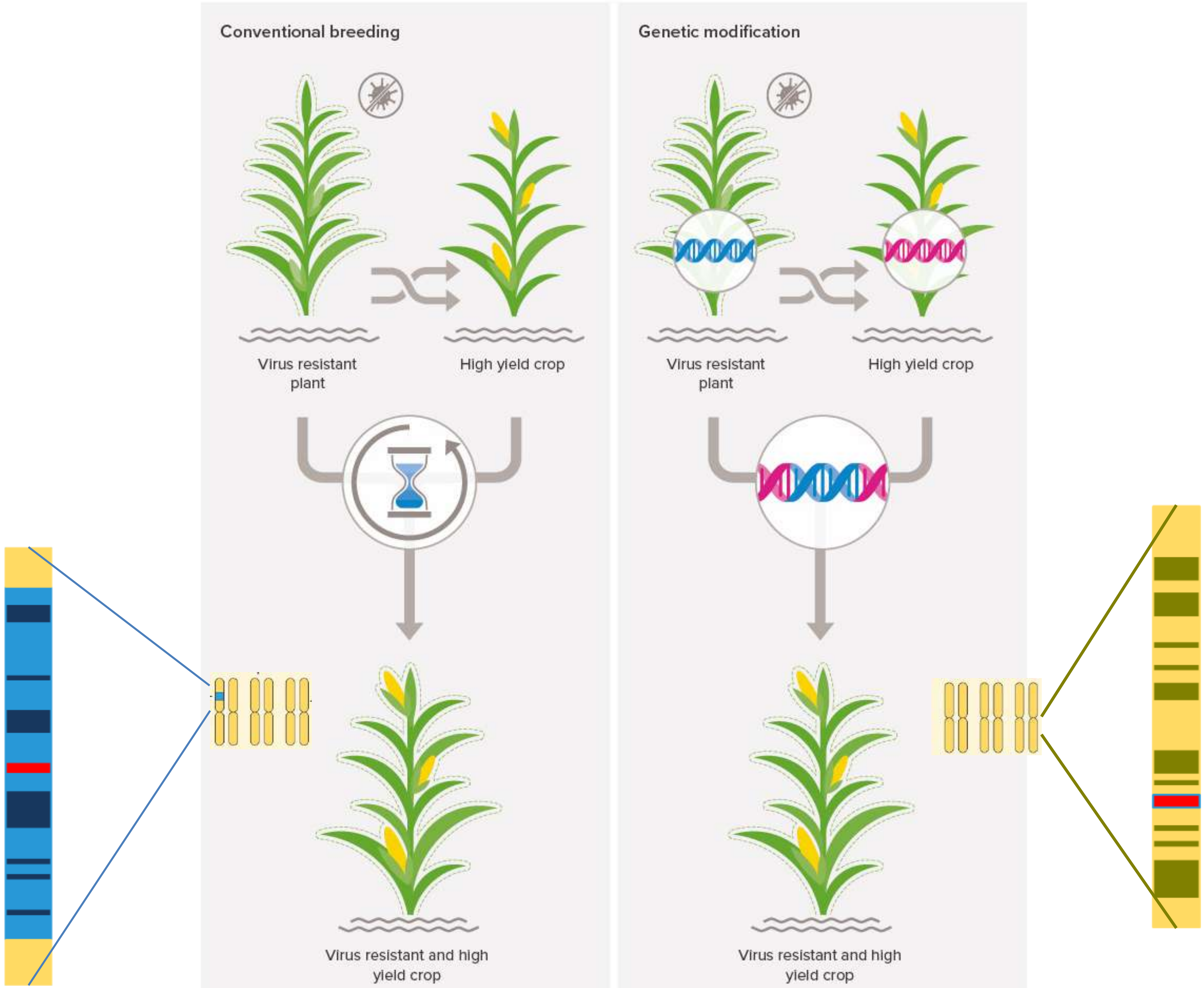


https://royalsociety.org/topics-policy/projects/gm-plants/how-does-gm-differ-from-conventional-plant-breeding/

Agrobacterium tumefaciens

De patógeno a ferramenta de engenharia genética de plantas

Galha-de-coroa

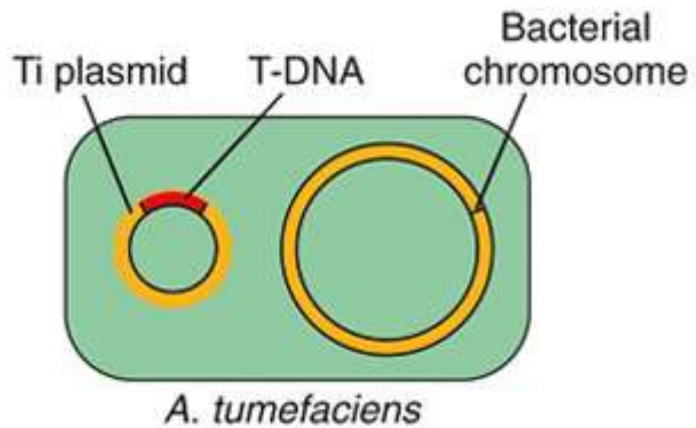
Primeiro registro escrito data de 1853 em plantas de uva

Fridiano Cavara (1897) encontra bactérias nos tumores

Galha de coroa induz a proliferação de uma massa celular em lesões, limitando a produtividade da planta

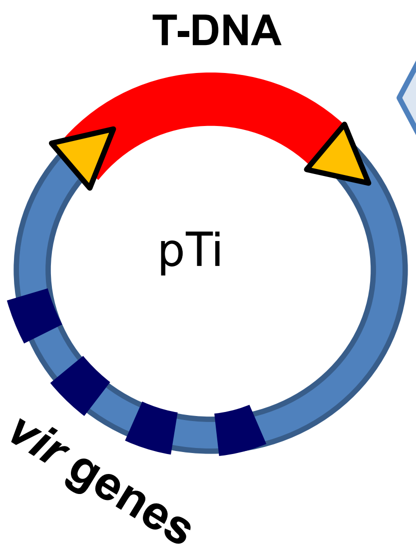
Edward L. Barnard, Florida Department of Agriculture and Consumer Services, Bugwood.org; Mike Ellis, Ohio State University; University of Georgia Plant Pathology Archive, University of Georgia, Bugwood.org; Wikimedia commons

DNA é transferido do plasmídio Ti plasmid para células das plantas (1977)



http://cms.daegu.ac.kr/sgpark/microbiology/agrobacterium.jpg

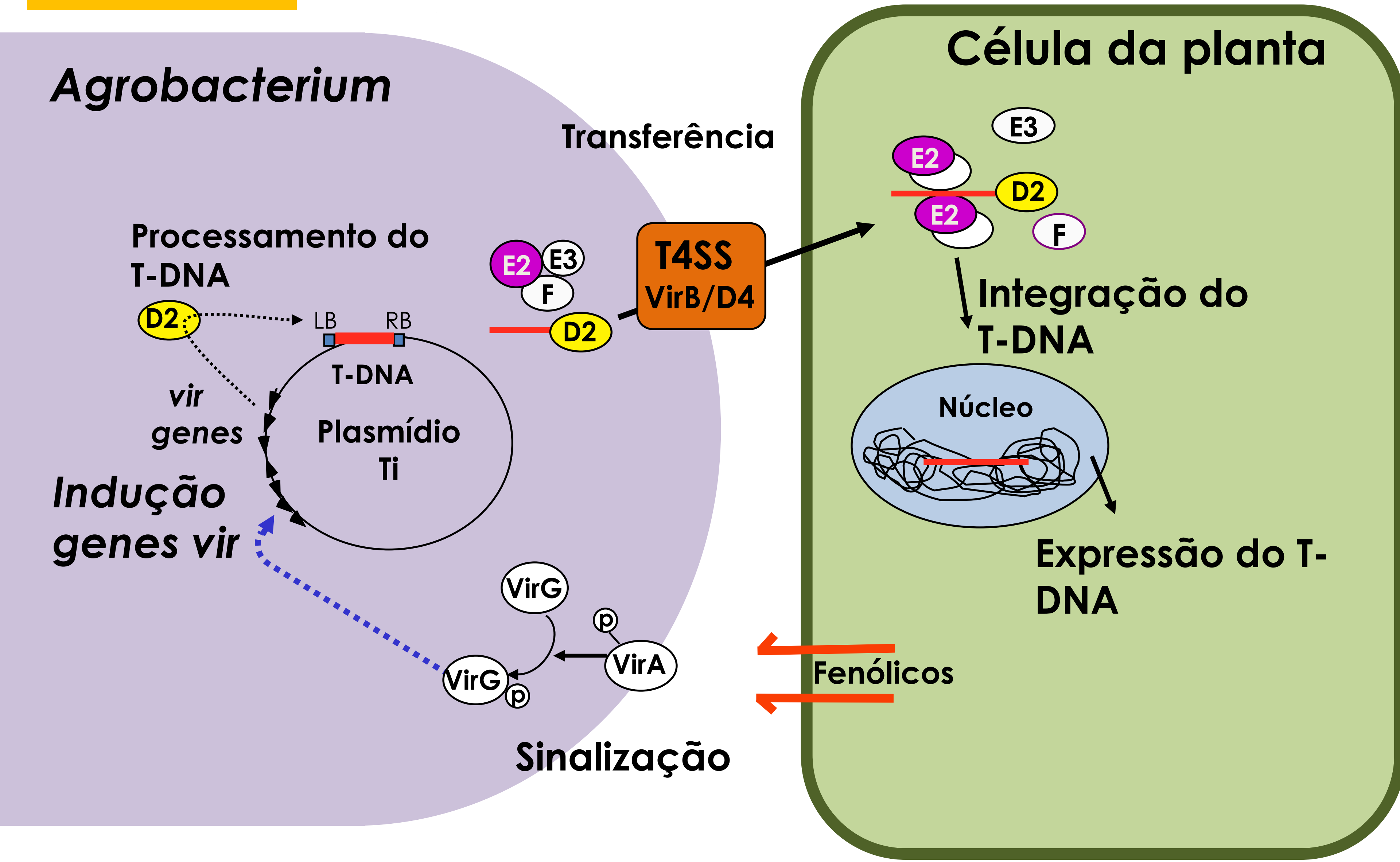
Estrutura e função do plasmídio Ti



Transfer DNA (T-DNA) move para o núcleo da célula da planta. É flanqueado por duas bordas consistindo de repetições de 25 bp (triangulos amarelos)

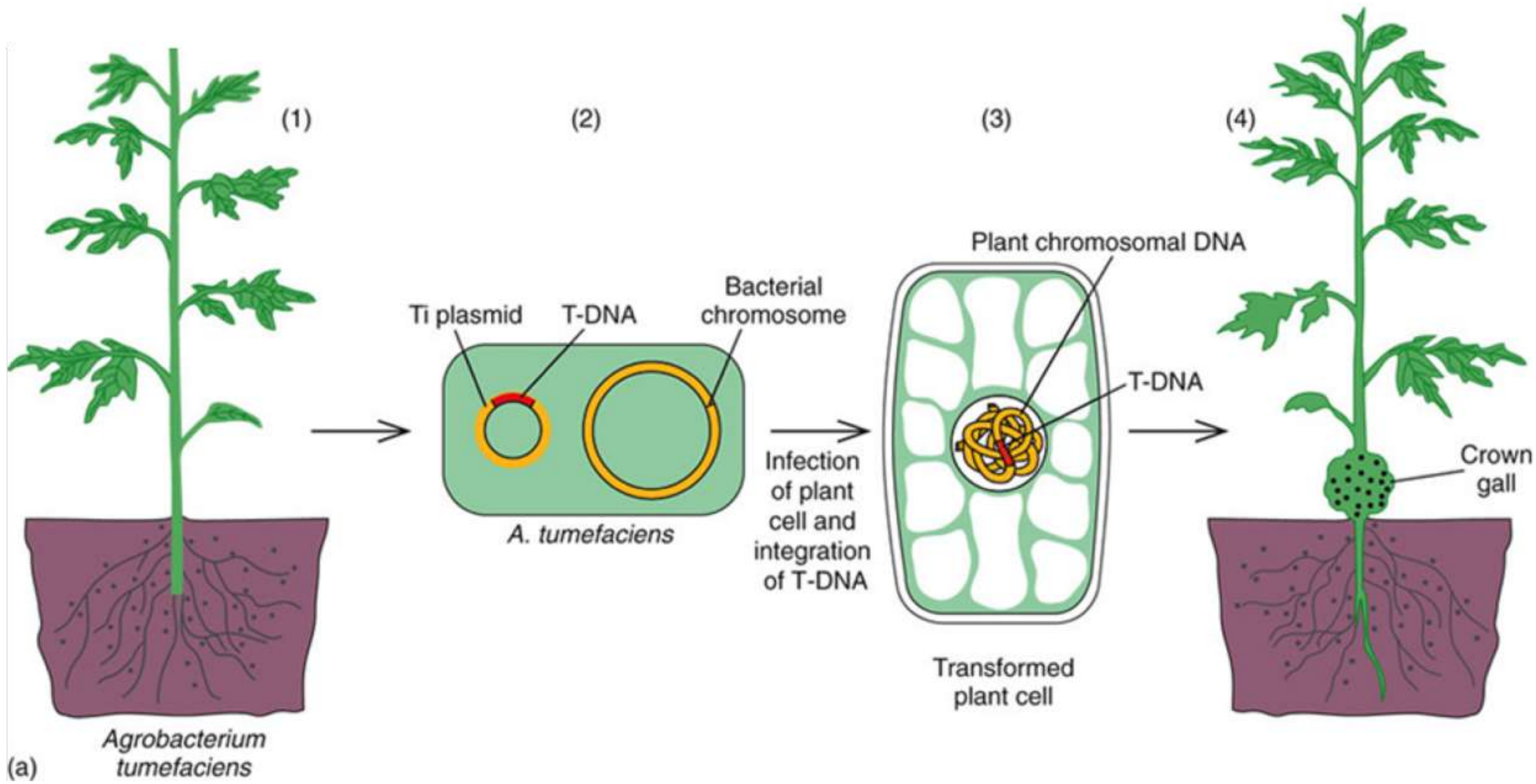
Genes *virulence* (*vir*) são necessários para a movimentação do T-DNA

RESUMO

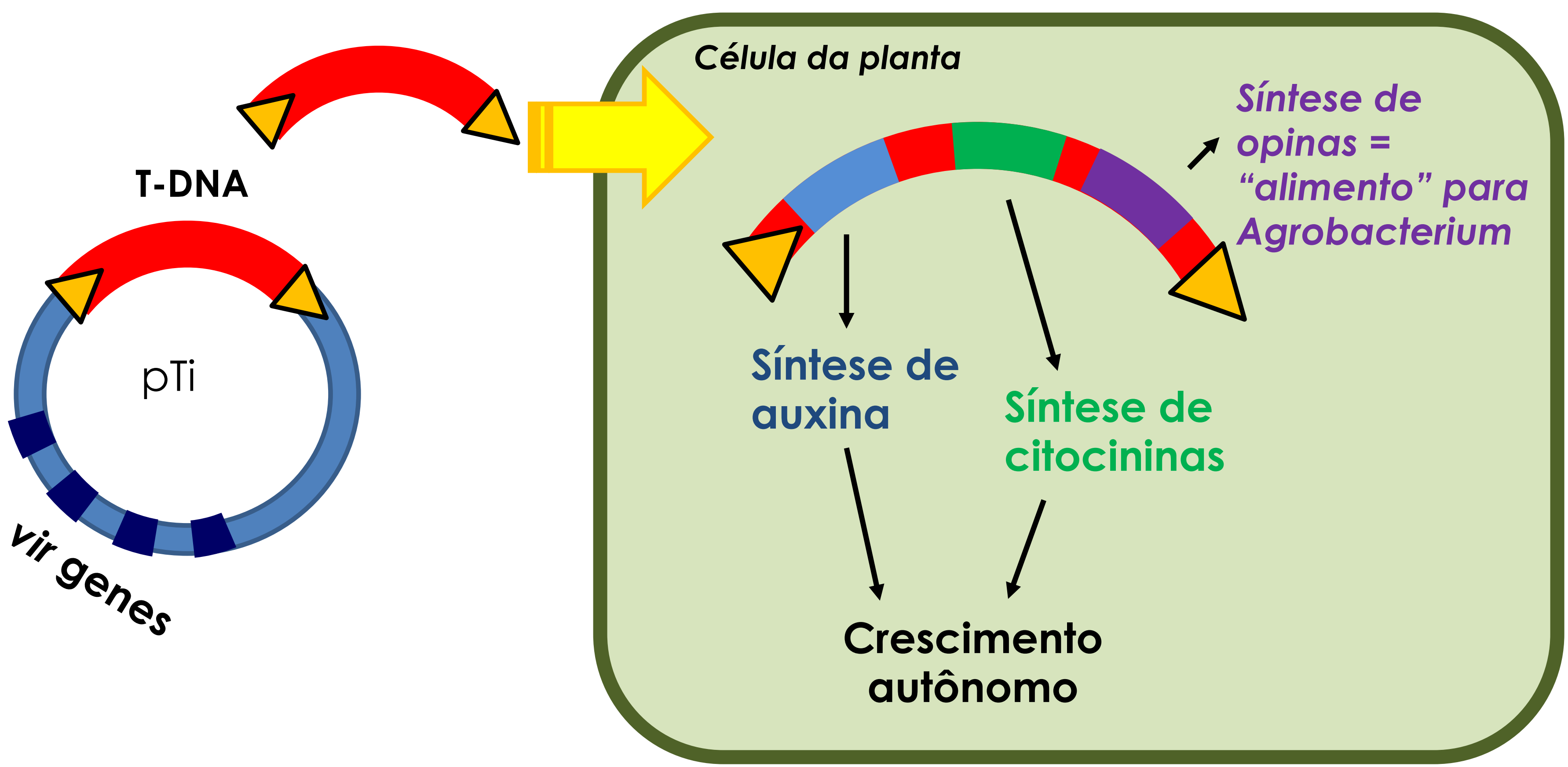


Agrobacterium
Célula da planta
Transferência
Processamento do T-DNA
D2
LB
RB
T-DNA
vir genes
Plasmídio Ti
Indução genes vir
E2
E3
F
D2
T4SS
VirB/D4
E3
E2
D2
E2
F
Integração do T-DNA
Núcleo
Expressão do T-DNA
VirG
p
VirA
VirG
p
Fenólicos
Sinalização

DNA é transferido do plasmídio Ti plasmid para células das plantas (1977)

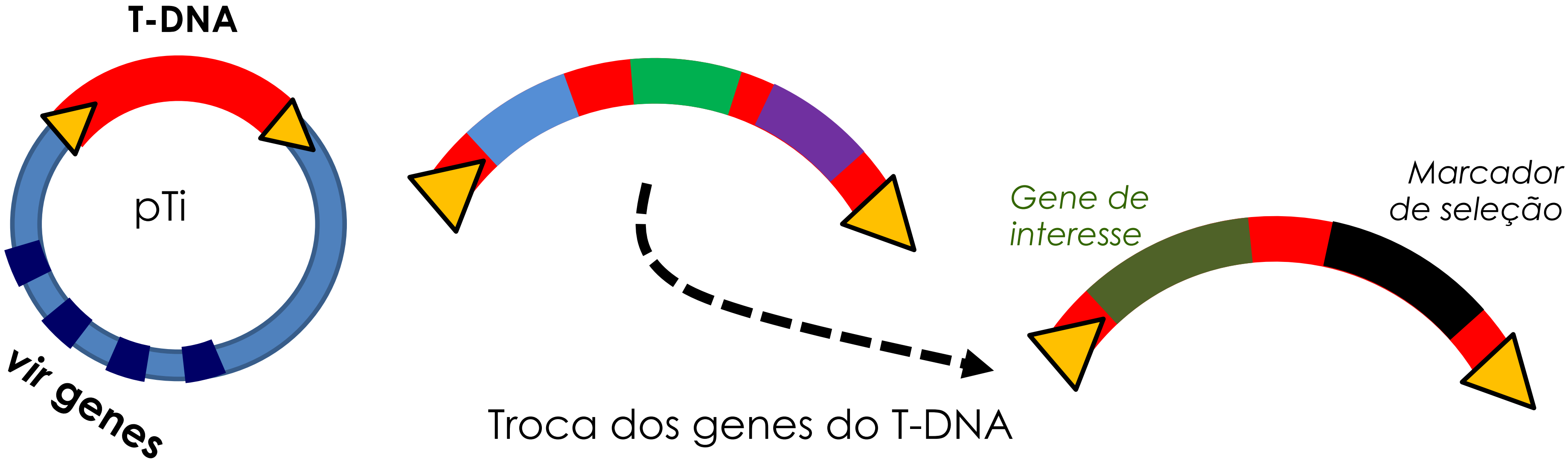


T-DNA : genes que induzem tumor e síntese de opinas

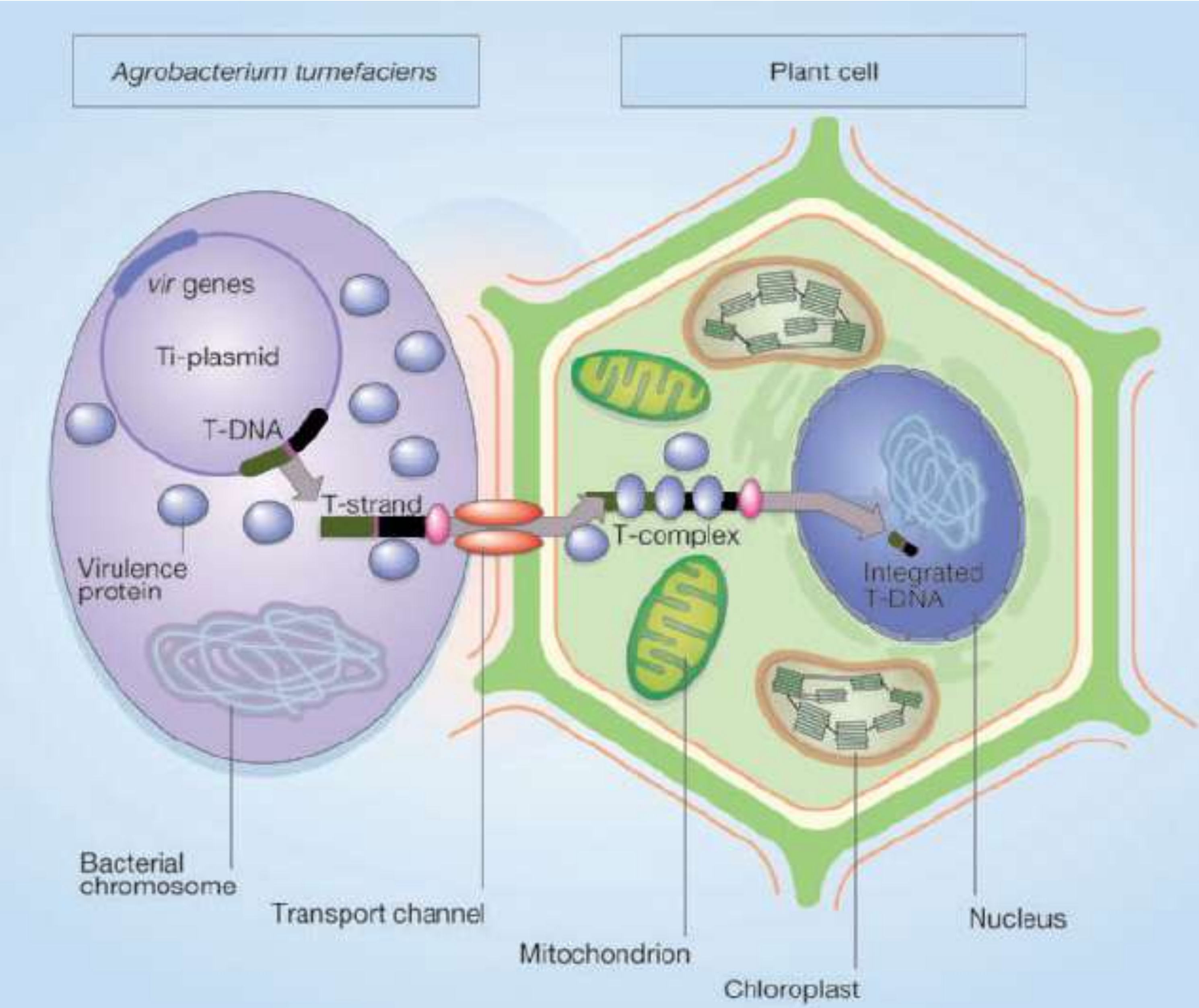


Utilização do T-DNA na biotecnologia

Mecanismo de transferência de um trecho de DNA do plasmídio Ti para o núcleo da célula vegetal



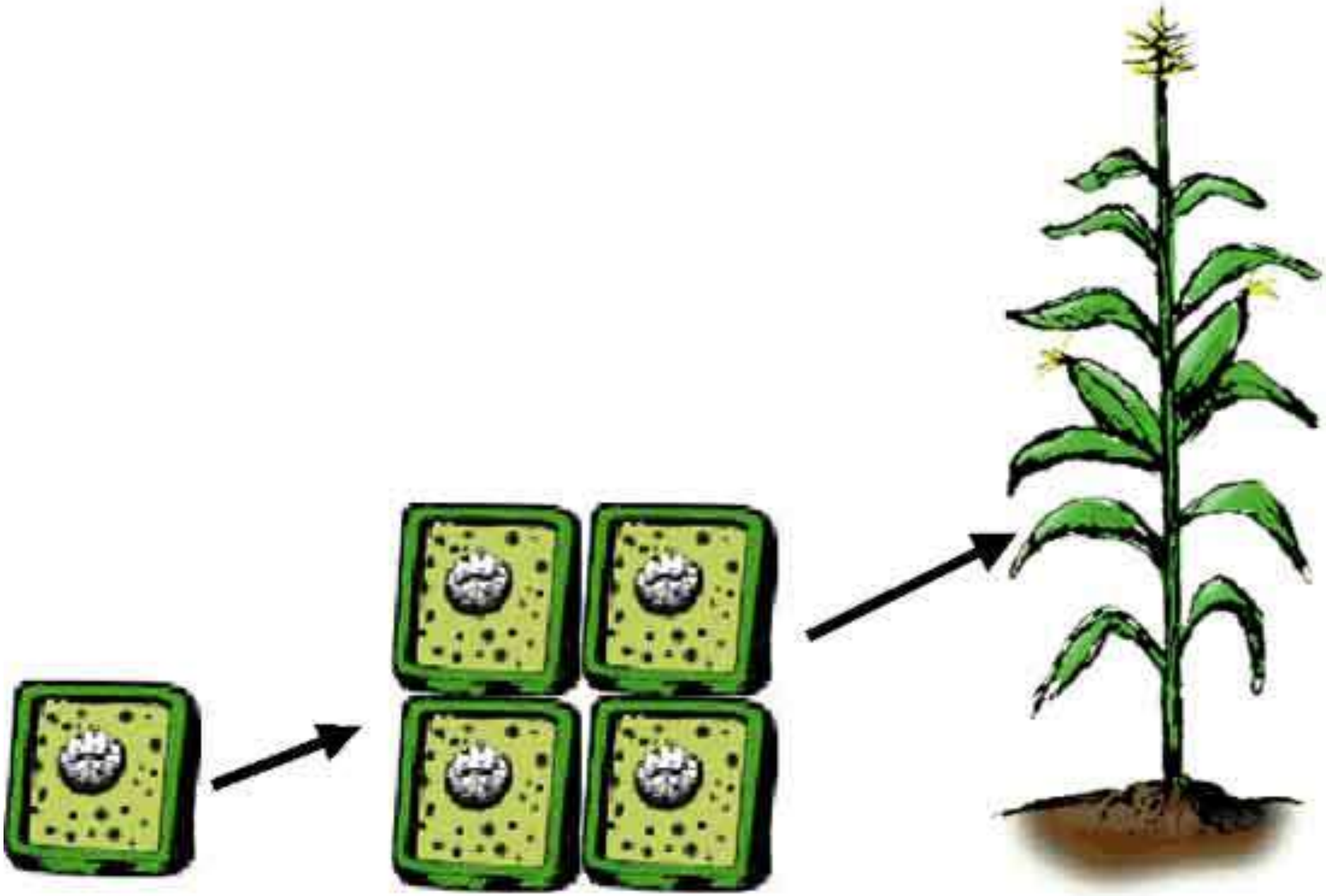
Hoekema, A., Hirsch, P.R., Hooykaas, P.J.J. and Schilperoort, R.A. (1983). A binary plant vector strategy based on separation of vir- and T-region of the *Agrobacterium tumefaciens* Ti-plasmid. Nature. 303: 179-180.



UMA célula transformada por *Agrobacterium*

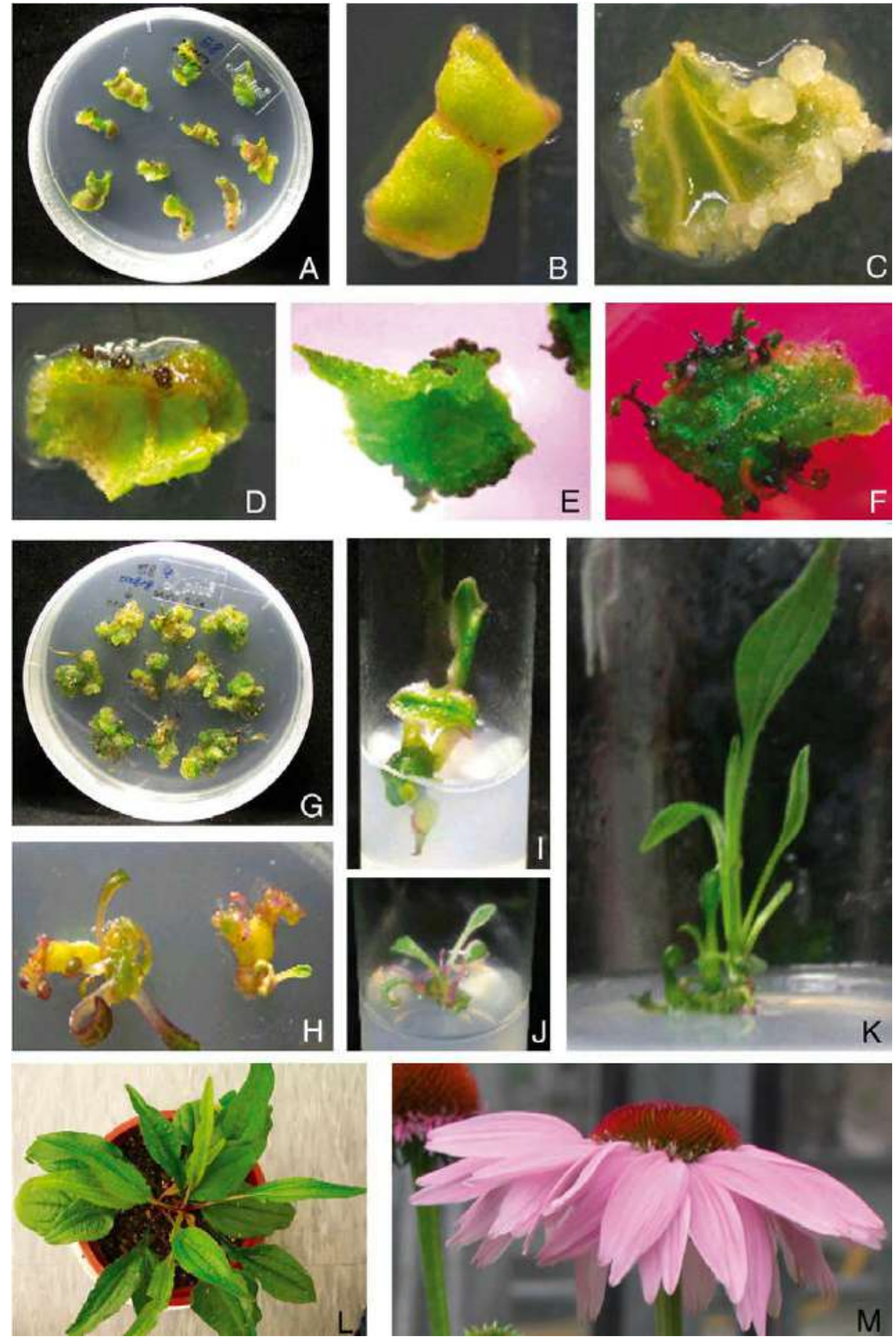
http://www.nature.com/nature/journal/v433/n7026/images/433583a-f2.2.jpg

REGENERAÇÃO

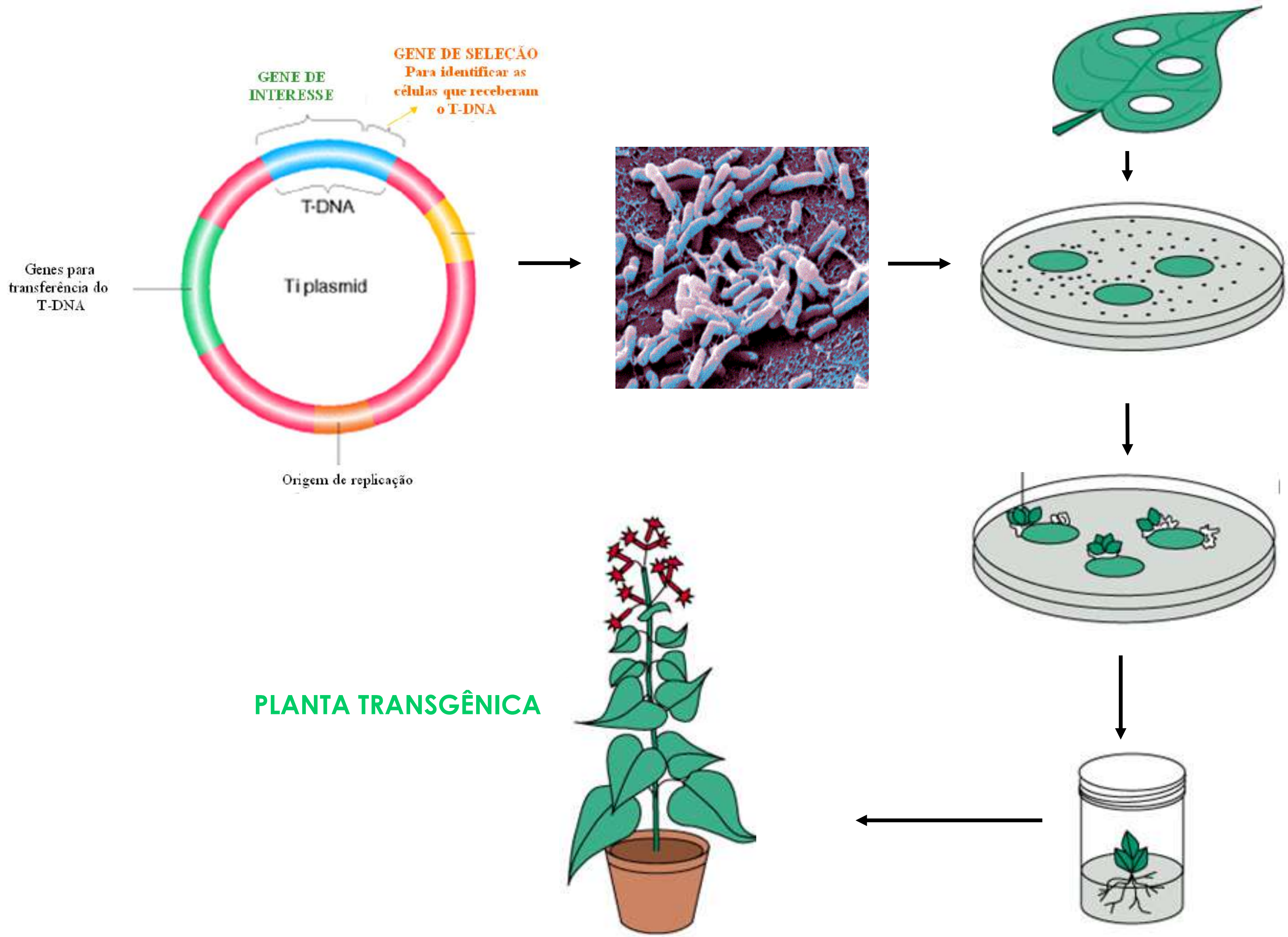


http://passel.unl.edu/Image/siteImages/CelltopltLG.jpg

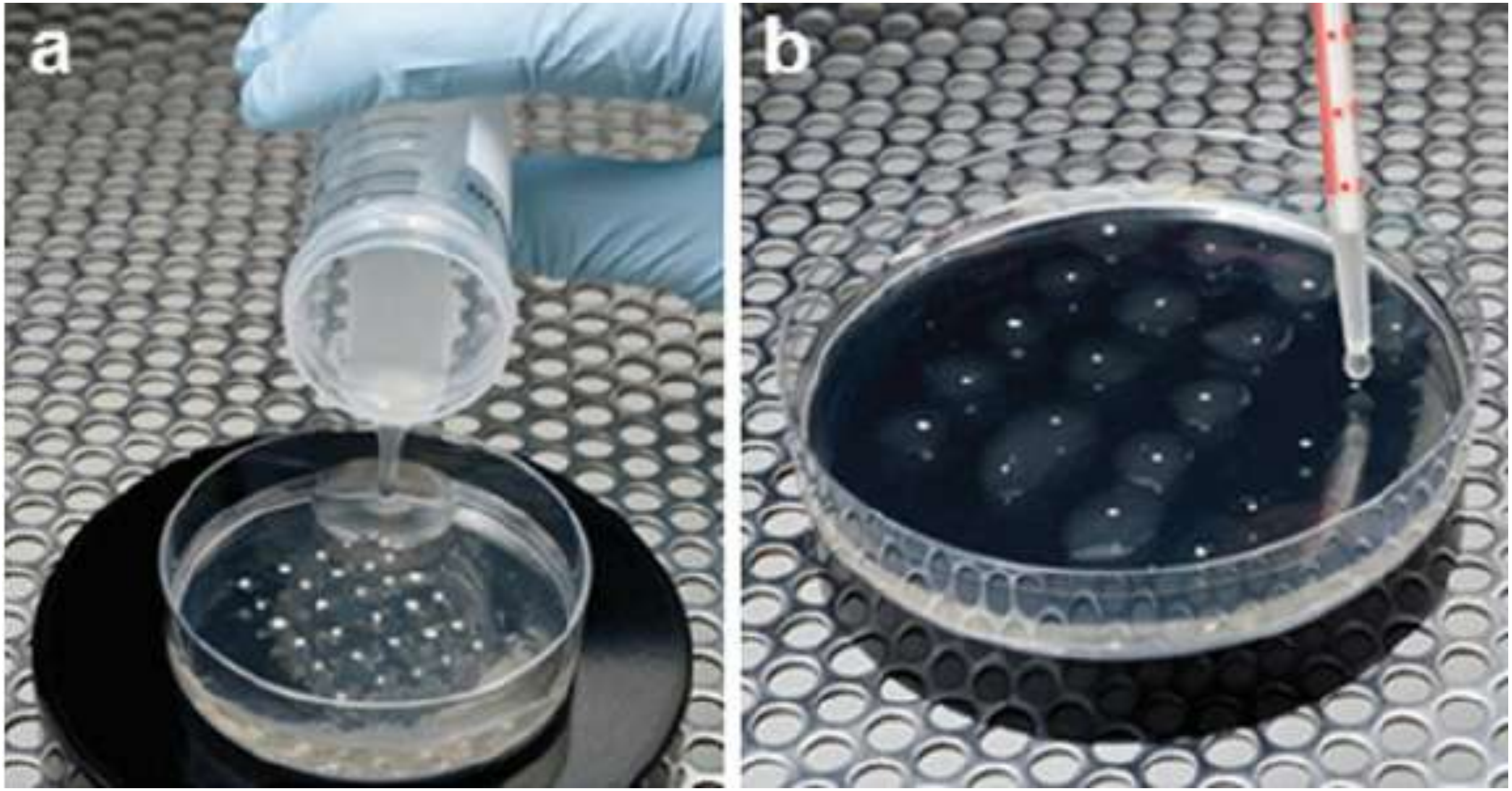
Alteração na composição do meio de cultura (fitormônios)



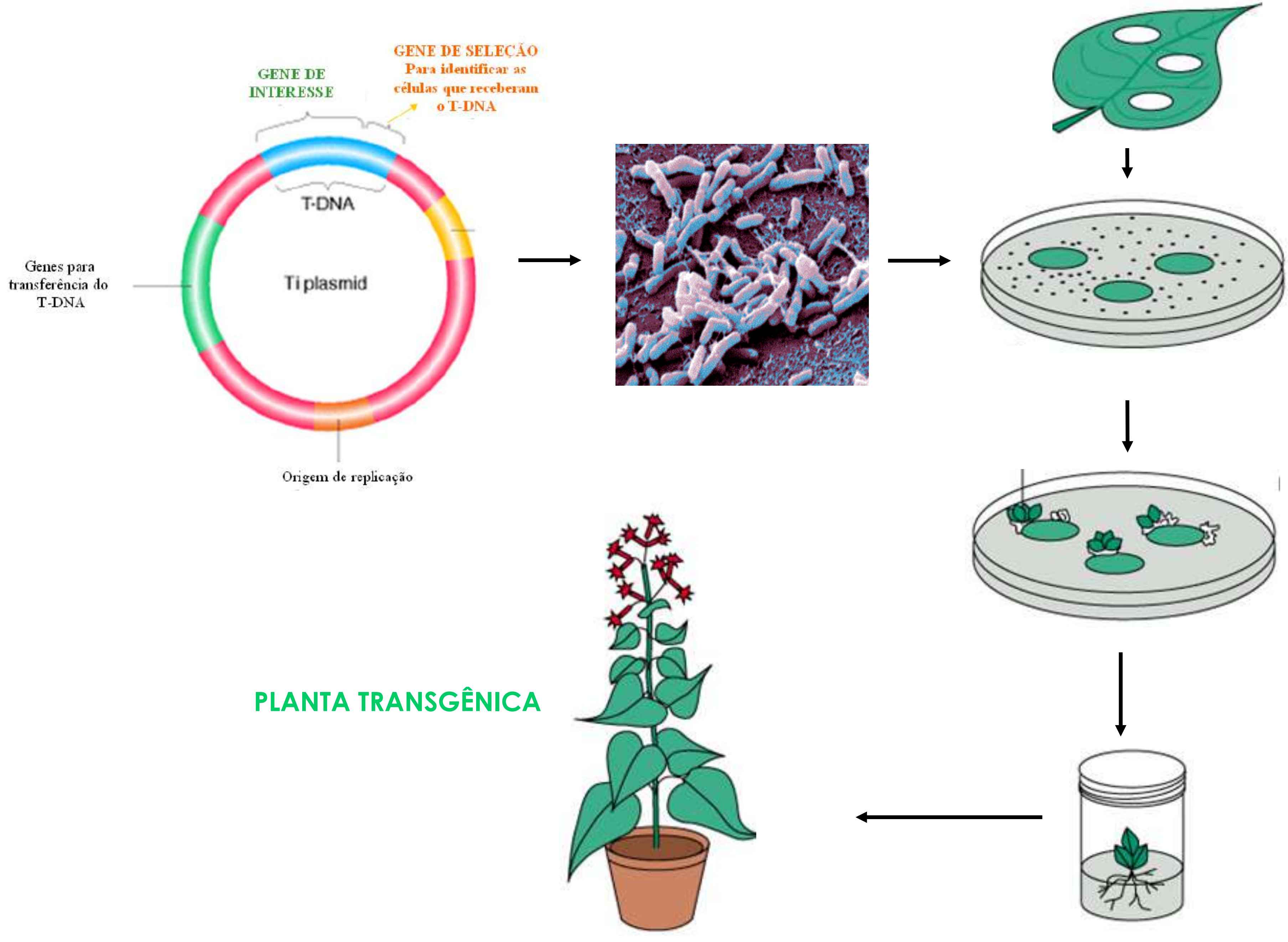
Transformação *via Agrobacterium*



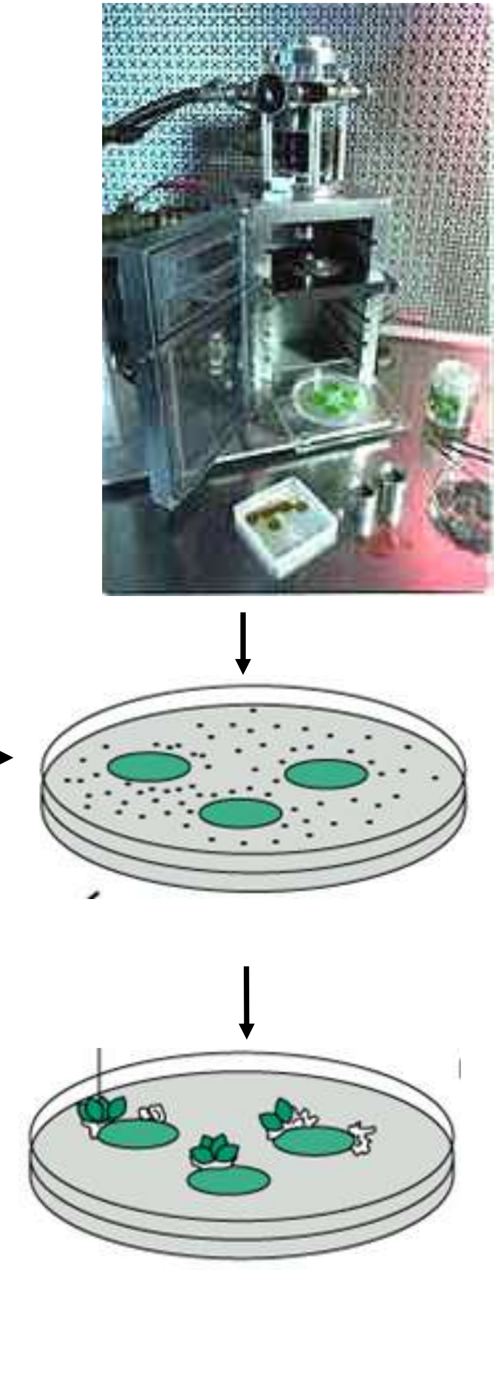
Co-cultivo com Agrobacterium

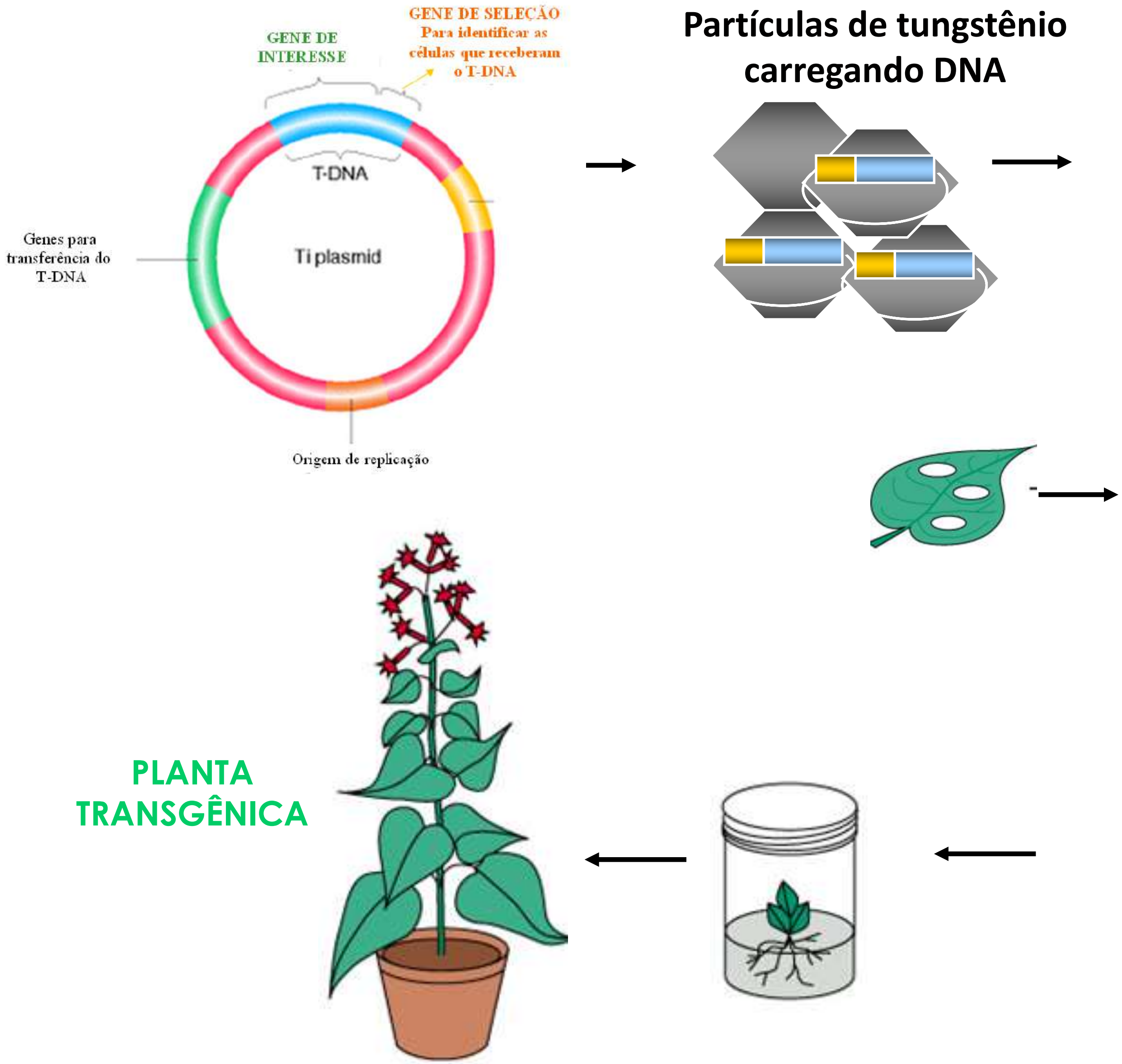


Transformação *via Agrobacterium*

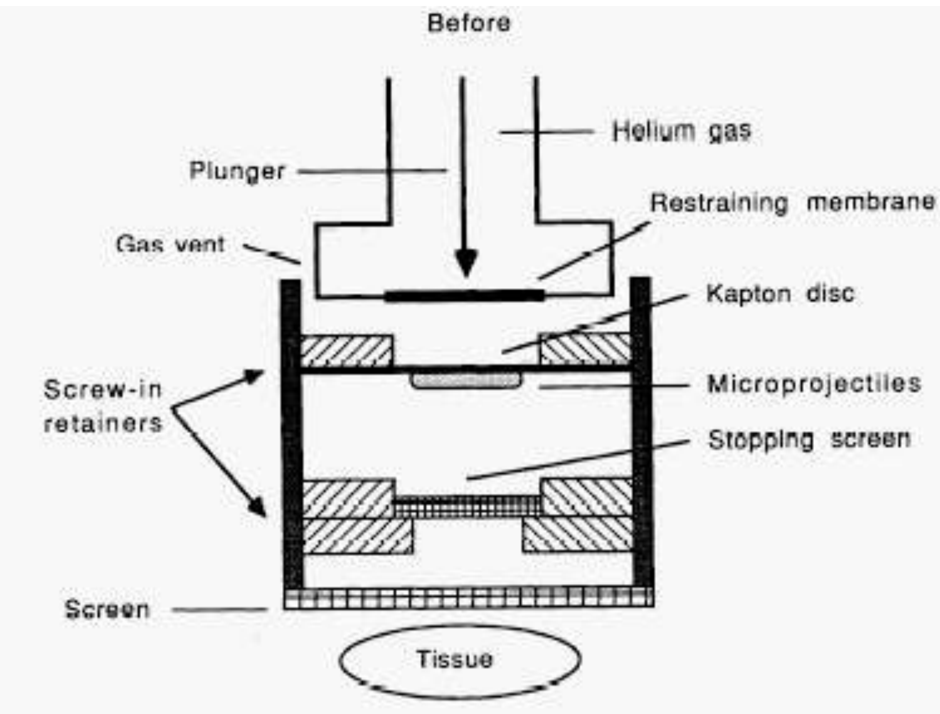


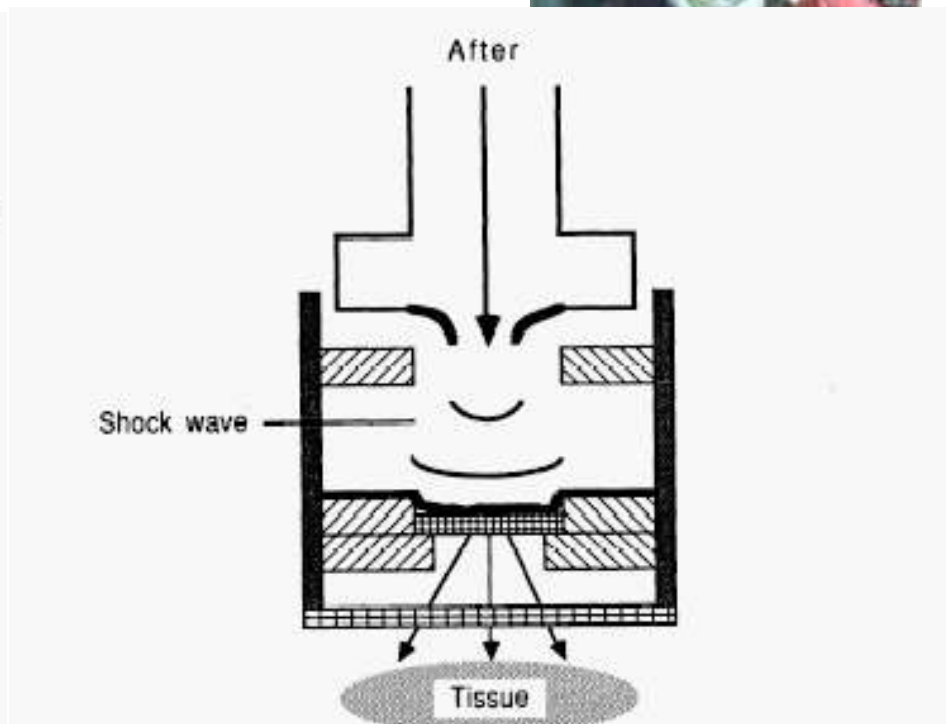
Transformação via bombardeamento: canhão gênico



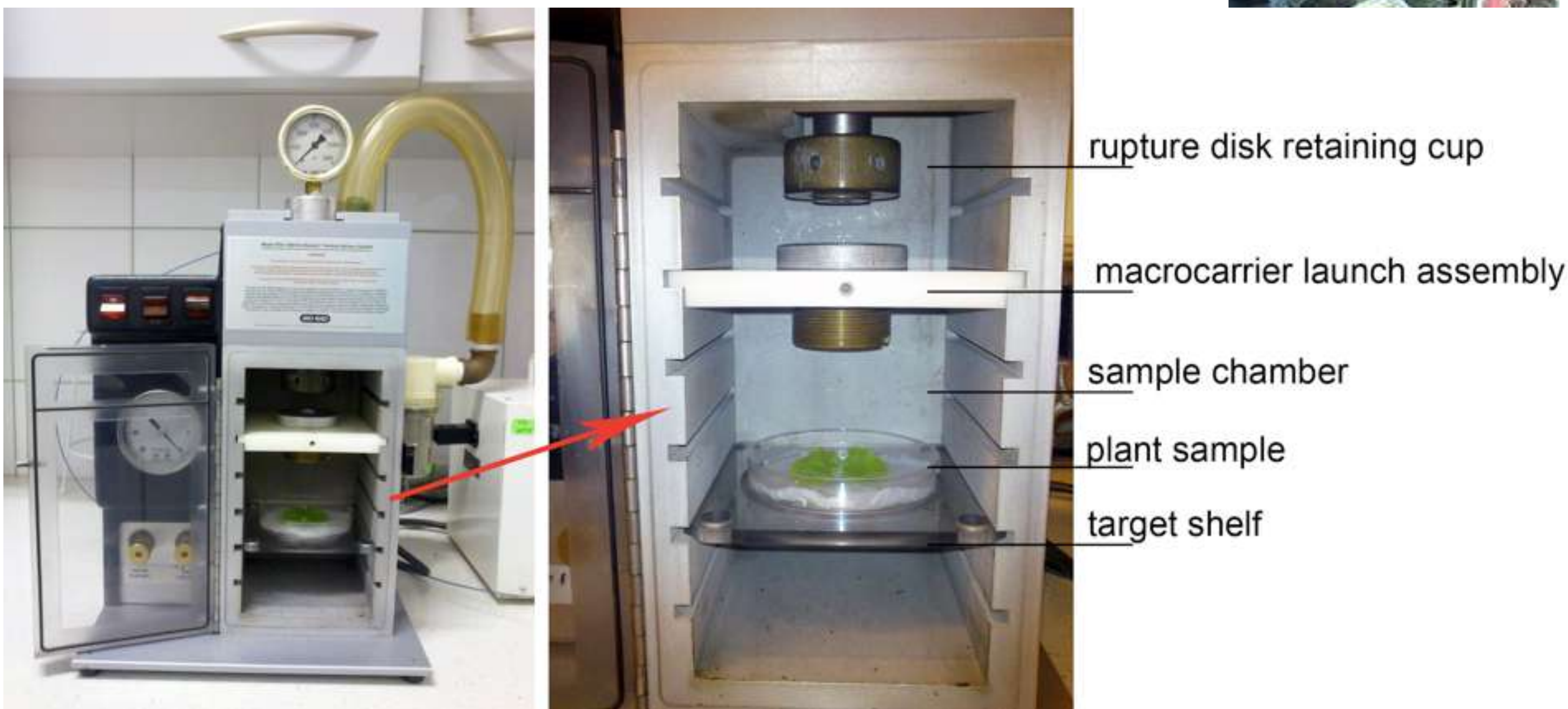


Transformação via bombardeamento: canhão gênico

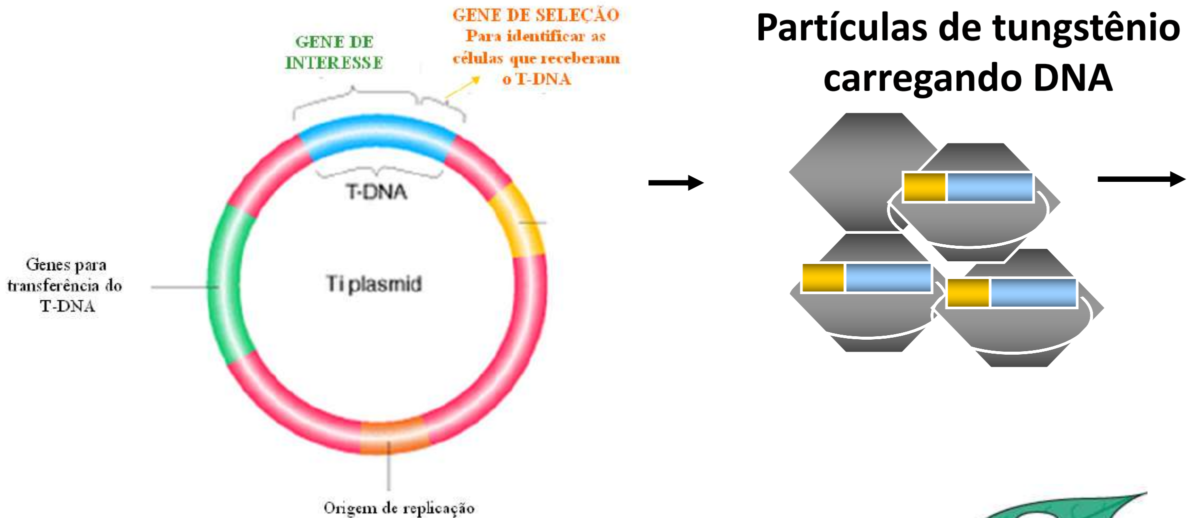


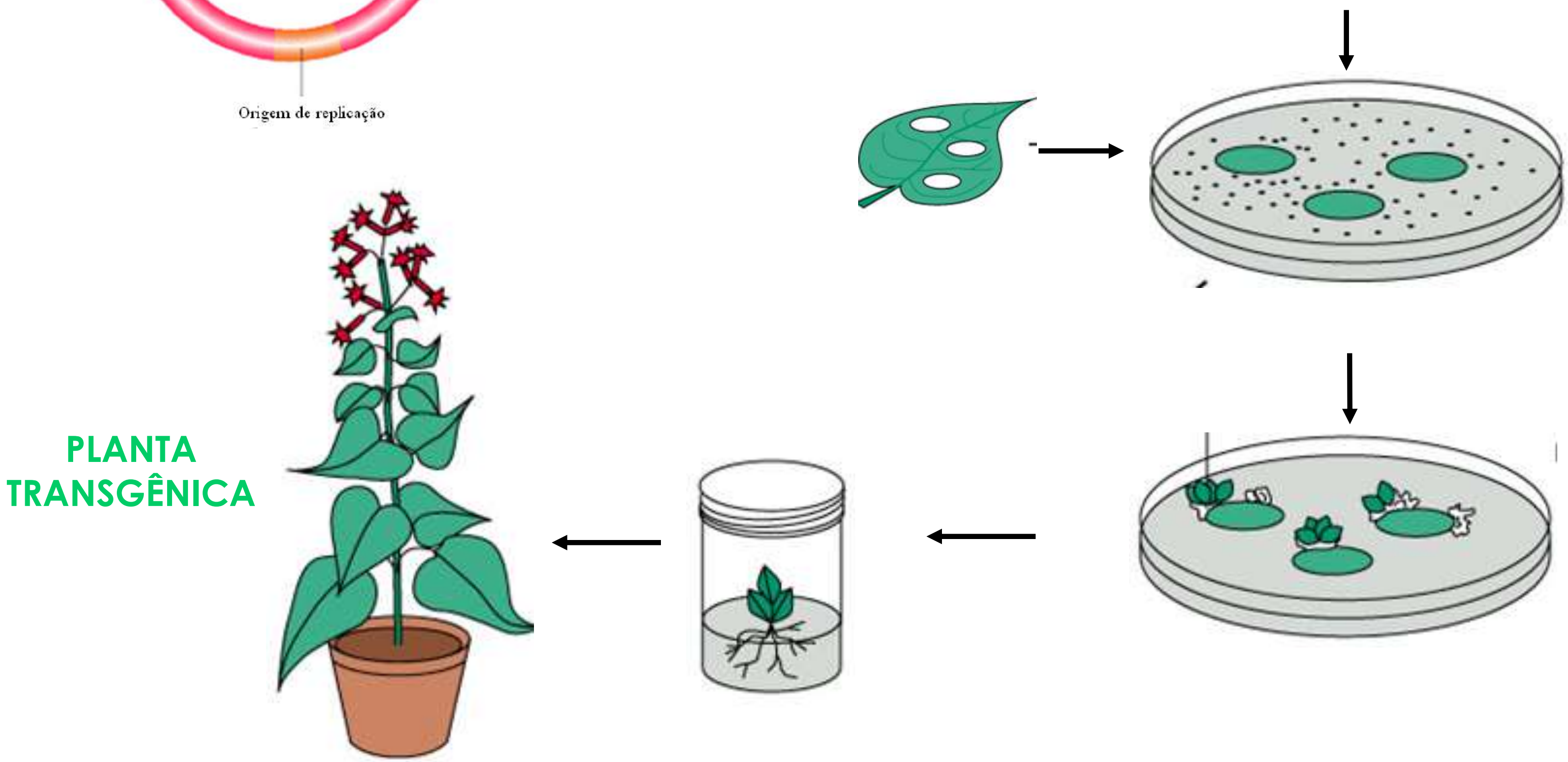


Transformação via bombardeamento: canhão gênico



Transformação via bombardeamento: canhão gênico





Transformação Genética:

- ***Auxiliar no estudo da biologia vegetal***

- ***Biotecnologia (melhoramento genético)***

- ***Expressão de gene***
(aumentar níveis de um existente no genoma ou introduzir novo gene)

- ***Silenciamento de gene***
(reduzir a quantidade de mRNA e consequentemente de proteína)

Estrutura de um gene

P (promotor): Controle transcricional (quanto, quando e onde expressará)
T (terminador): final da transcrição do gene

Sequência codificante= o que se deseja expressar: região codificante de uma proteína ou estrutura de silenciamento gênico

5'UTR e 3'UTR: sequencias regulatória de tradução.

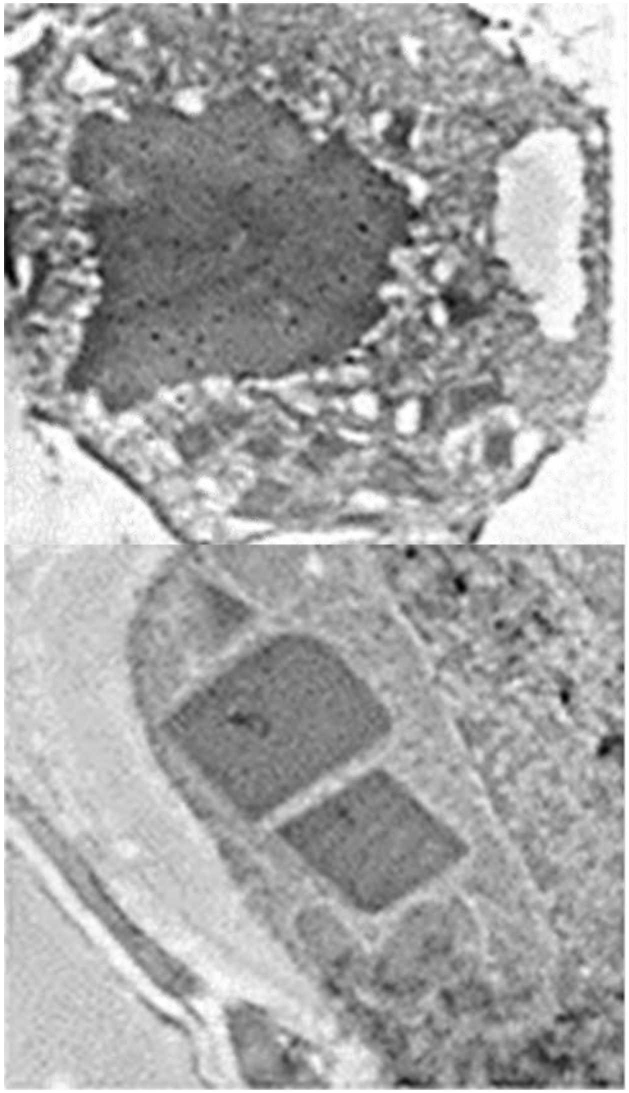
- ***Expressão de gene***

(aumentar níveis de um existente no genoma ou introduzir novo gene)

- ***Silenciamento de gene***

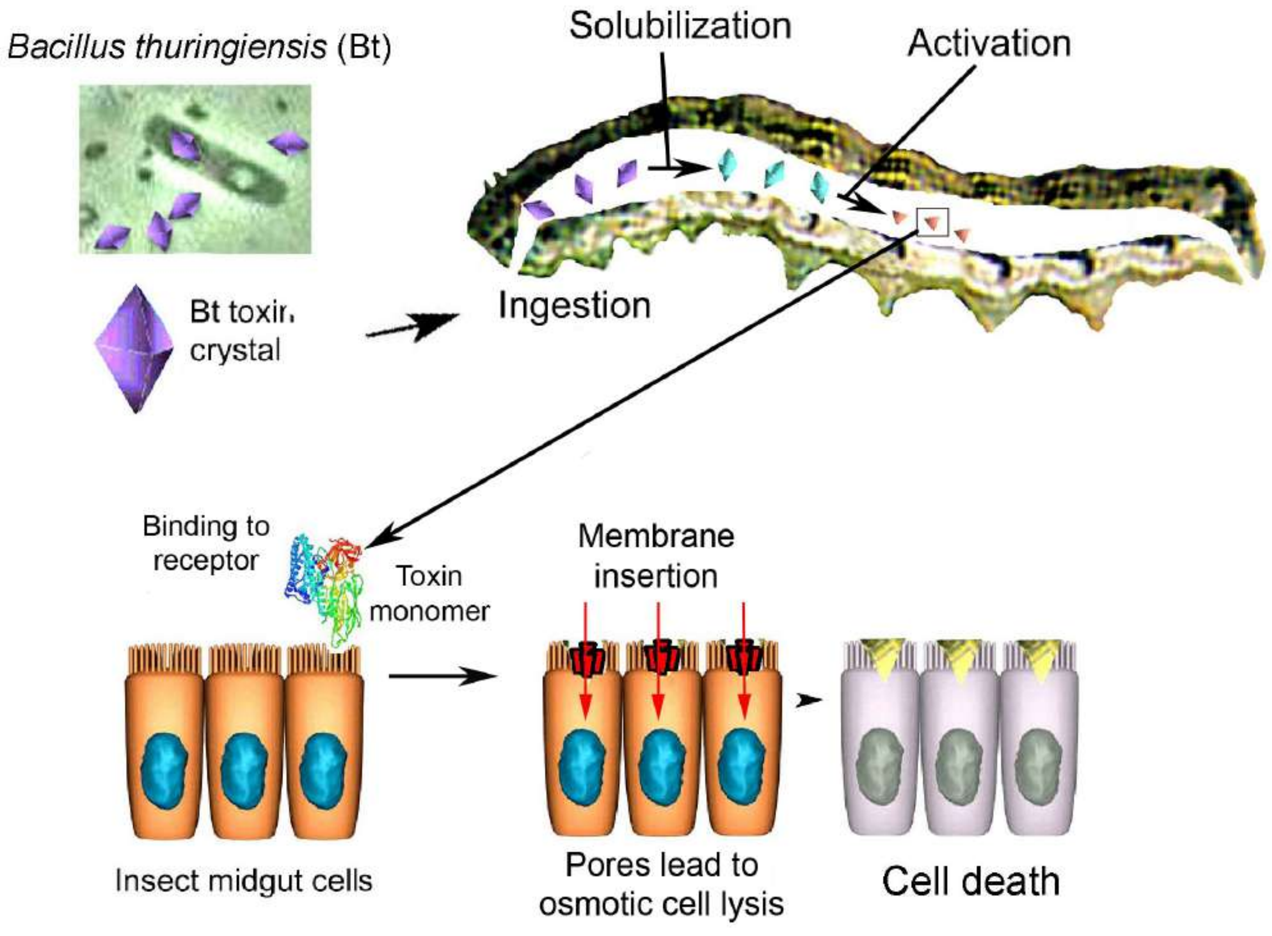
(reduzir a quantidade de mRNA e consequentemente de proteína)

Resistência a insetos: genes *Bt* de *Bacilus turingensis*



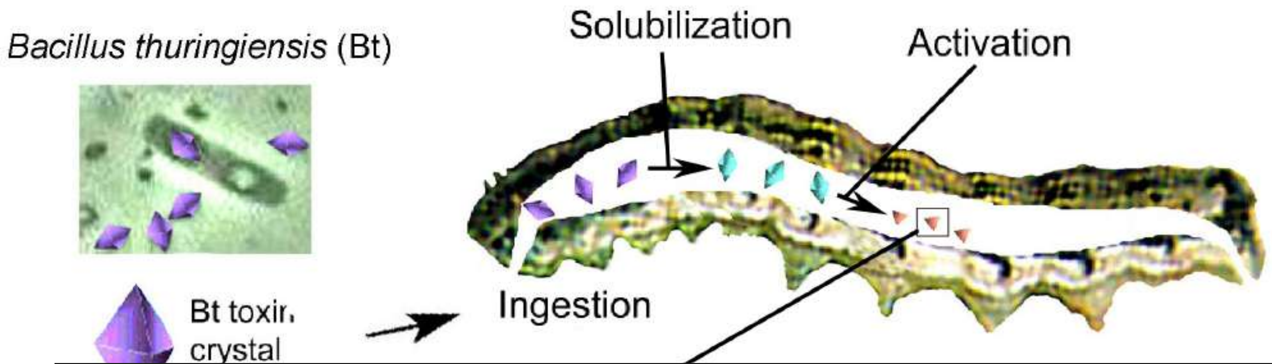
Country	Insecticide reduction	Increase in effective yield	Increase in gross margin	References
	—— % ——		US$ ha^{-1}	
Argentina	47	33	23	Qaim and de Janvry, 2005
Australia	48	0	66	Fitt, 2003
China	65	24	470	Pray *et al.*, 2002
India	41	37	135	Subramanian and Qaim, 2009
Mexico	77	9	295	Traxler *et al.*, 2003
USA	36	10	58	Carpenter *et al.*, 2002

Resistência a insetos: genes *Bt* de *Bacilus turingensis*



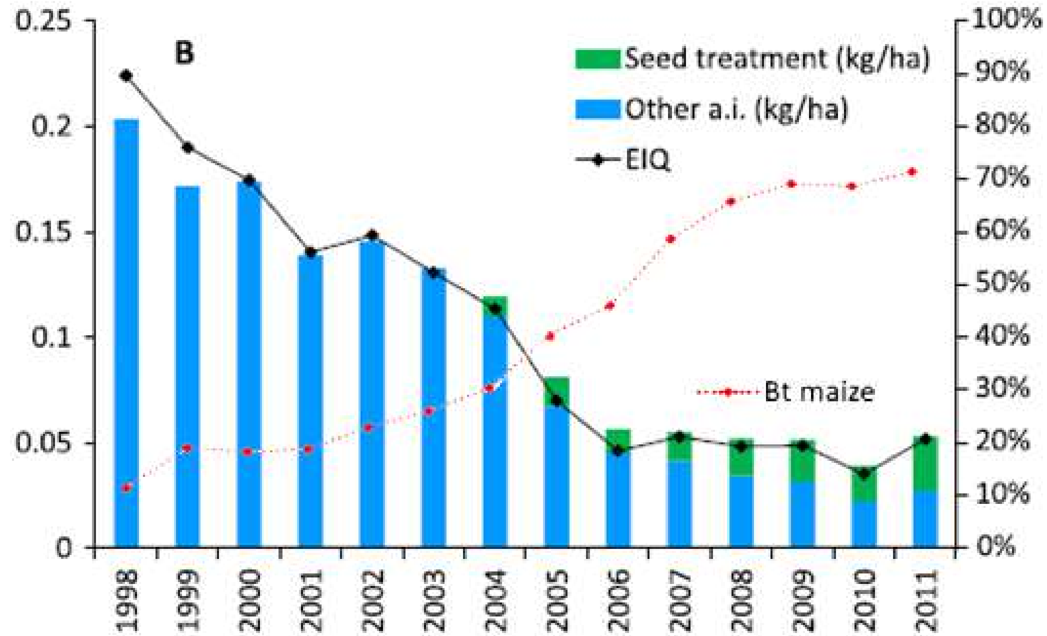
Jurat-Fuentes Laboratory
(http://web.utk.edu/~jurat/)

Resistência a insetos: genes *Bt* de *Bacilus turingensis*



Resistência a insetos: genes *Bt* de *Bacilus turingensis*

Queda do impacto ambiental com o uso de transgênicos resistentes a insetos



EIQ: Environmental Impact Quotient
a.i. : Active Ingredient

Perry, E. D., Ciliberto, F., Hennessy, D. A., & Moschini, G. (2016). Genetically engineered crops and pesticide use in US maize and soybeans. *Science advances*, *2*(8), e1600850.

- Snow, A. A., Pilson, D., Rieseberg, L. H., Paulsen, M. J., Pleskac, N., Reagon, M. R., ... & Selbo, S. M. (2003). A Bt transgene reduces herbivory and enhances fecundity in wild sunflowers. Ecological applications, 13(2), 279-286.
- Niu, L., Mannakkara, A., Qiu, L., Wang, X., Hua, H., Lei, C., ... & Ma, W. (2017). Transgenic Bt rice lines producing Cry1Ac, Cry2Aa or Cry1Ca have no detrimental effects on Brown Planthopper and Pond Wolf Spider. Scientific reports, 7(1), 1940.
- Yao, Y. S., Han, P., Niu, C. Y., Dong, Y. C., Gao, X. W., Cui, J. J., & Desneux, N. (2016). Transgenic Bt cotton does not disrupt the top-down forces regulating the cotton aphid in central China. *PloS one*, *11*(11), e0166771.
- Raen, A. Z., Cong, D. A. N. G., Fang, W. A. N. G., PENG, Y. F., & YE, G. Y. (2016). Thrips-mediated impacts from transgenic rice expressing Cry1Ab on ecological fitness of non-target predator Orius tantilus (Hemiptera: Anthocoridae). *Journal of integrative agriculture*, *15*(9), 2059-2069.
- Fleming, D., Musser, F., Reisig, D., Greene, J., Taylor, S., Parajulee, M., ... & Stewart, S. (2018). Effects of transgenic Bacillus thuringiensis cotton on insecticide use, heliothine counts, plant damage, and cotton yield: A meta-analysis, 1996-2015. *PloS one*, *13*(7), e0200131.
- Li, L., Yang, X., Wang, L., Yan, H., Su, J., Wang, F., & Lu, B. R. (2016). Limited ecological risk of insect-resistance transgene flow from cultivated rice to its wild ancestor based on life-cycle fitness assessment. *Science bulletin*, *61*(18), 1440-1450.
- Jin, L., Zhang, H., Lu, Y., Yang, Y., Wu, K., Tabashnik, B. E., & Wu, Y. (2015). Large-scale test of the natural refuge strategy for delaying insect resistance to transgenic Bt crops. *Nature biotechnology*, *33*(2), 169.
- Guo, J., He, K., Hellmich, R. L., Bai, S., Zhang, T., Liu, Y., ... & Wang, Z. (2016). Field trials to evaluate the effects of transgenic cry1Ie maize on the community characteristics of arthropod natural enemies. *Scientific reports*, *6*, 22102.
- Shahid, A. A., Bano, S., Khalid, S., Samiullah, T. R., Bajwa, K. S., & Ali, M. A. (2016). Biosafety assessment of transgenic Bt cotton on model animals. *Advancements in Life Sciences*, *3*(3), 97-108.

Resistência a insetos: genes *Bt* de *Bacilus turingensis*

Cotton - *Gossypium hirsutum L.* : 49 Events
Cowpea (feijão de corda) - *Vigna unguiculata* : 1 Event
Eggplant - *Solanum melongena* : 1 Event
Maize - *Zea mays L.* : 119 Events
Rice - *Oryza sativa L.* : 3 Events
Soybean - *Glycine max L.* : 6 Events
Sugarcane - *Saccharum sp* : 3 Events
Tomato - *Lycopersicon esculentum* : 1 Event

https://www.isaaa.org

Aumentar a qualidade nutricional das culturas: Arroz com pro-vitamina A (carotenoides)

Golden Rice 2nd generation

Phytoene desaturase (*CRTI*) from *Erwinia uredovora*

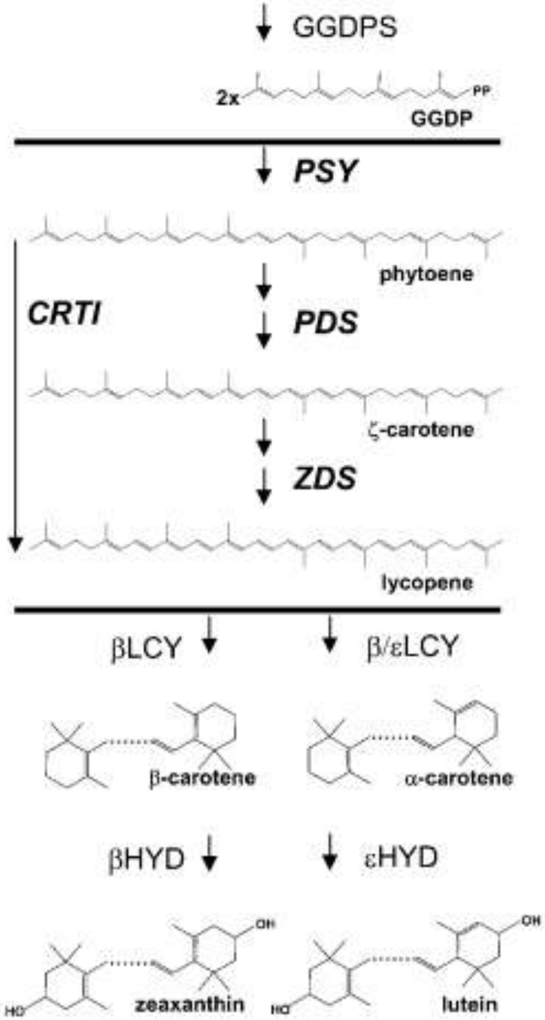


Figure 1. Carotenoid biosynthesis in transgenic rice endosperm. The precursor molecule geranylgeranyl-diphosphate (GGDP) is synthesized in wild-type endosperm. The enzymatic activities between horizontal bars are supplemented by transformation. This can be done either by using the two plant-type desaturases, PDS and ZDS, or by using the bacterial carotene desaturase, CrtI. However, lycopene does not appear as a product; instead, the carotenoids shown below the bottom bar are found in transgenic endosperm, among which β-carotene is predominant.

PSY from maize (*Zea mays*)

Golden Rice Project

Golden Rice Humanitarian Board

Golden Rice is part of the solution

Allow Golden Rice to save lives

Opinion

An Opinion paper by Felicia Wu and colleagues, published in the Proceedings of the National Academy of Sciences USA (PNAS) in December 2021, notes that 20 years after Golden Rice was first obtained by Ingo Potrykus and Peter Beyer, the tragedy we face is that this brilliant scientific success is opaqued by regulatory delays that have only led to a perpetuation of immense grief and huge losses in terms of preventable deaths, with no reported apparent benefits to consumers or the environment brought about by the overprecautionary stance of the authorities involved in the decision-making process. The urgency of getting Golden Rice approved has become more apparent, and even more urgent, with the ongoing pandemic, which has made access to healthcare services more difficult in vulnerable populations worldwide.

The World Bank recommends that micronutrient biofortification of staple crops, including specifically Golden Rice, should be the norm and not the exception in crop breeding. Golden Rice can effectively control vitamin A deficiency (VAD) and its deadly consequences, especially for children. Delaying the uptake of a genetically modified product shown to have clear health benefits has and will cost numerous lives, frequently of the most vulnerable individuals. VAD has cost more lives than the current pandemic already! Policymakers must find ways to overcome this resistance and accelerate the introduction and adoption of Golden Rice.

158 Nobel Laureates praise Philippines move

Richard J Roberts, 1993 Nobel Prize Winner in Physiology or Medicine, on behalf of the 157 Nobel Prize winners and 13,292 co-signers supporting GMOs, have expressed their delight with the recent announcement of the move by the Philippine Department of Agriculture to authorize the direct use of Golden Rice as food and feed or for Processing. Visit Support Precision Agriculture.

Supplementation not sustainable

Pandemic affects supplementation programs

According to the United Nations

Bangladesh

DhakaTribune

TODAY'S PAPER NEWS BUSINESS SPORTS OPINION D2 MORE বাংলা

Home / Bangladesh / Agriculture

Minister: Golden Rice to be released soon

Tribune Desk Published at 12:04 am February 1st, 2019

Agriculture Minister Dr Abdur Razzak Mahmud Hossain Opu/Dhaka Tribune

JUST IN

07:00 pm Videos show Ducsu VP candidate Nur collapsing DHAKA

06:09 pm VC: Ducsu polls held peacefully, with few isolated incidents ELECTION

05:55 pm Water supply to Sajek cottages cut off NATION

05:49 pm Ducsu polls: Chhatra League VP candidate calls demand for re-election irrational ELECTION

Dr Razzak said: "Golden rice is more important than the other varieties of rice as it will be helpful to **fight the vitamin A deficiency**. **The rice variety has already got clearance in USA, Canada and Australia.**

"A committee of the Ministry of Environment will give the clearance for the production of Golden rice. We will be able to start cultivation of the rice in Bangladesh **within two-three months upon getting ministry clearance**," he said.

Filipinas – Aprovado 2020

Golden Rice rolling out in 7 provinces

By: Jordeene B. Lagare - @inquirerdotnet   Philippine Daily Inquirer / 05:45 AM April 08, 2022

YEARS IN THE MAKING The International Rice Research Institute (Irri) spent two decades with PhilRice to develop Golden Rice, which is touted to be helpful in preventing childhood blindness and malnutrition. Environmental groups, however, have strongly opposed the effort. —Isagani Serrano/IRRI

MANILA, Philippines — The genetically modified Golden Rice, a variety enriched with nutrients, is finally ready for planting in farms in seven provinces with a high incidence of malnutrition and stunting.

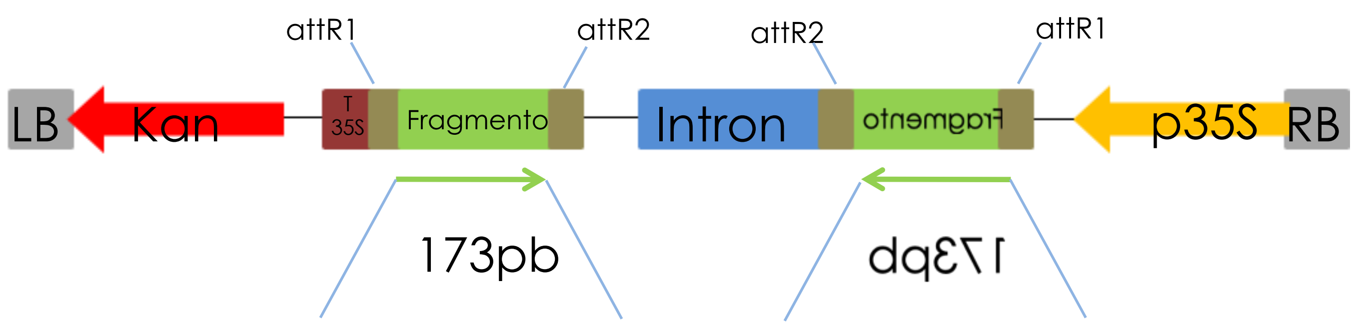
- ***Expressão de gene***

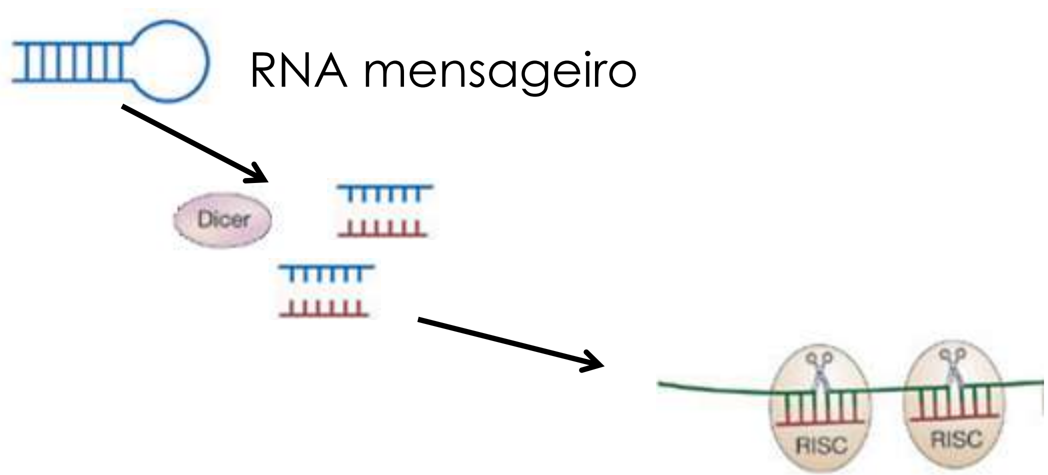
(aumentar níveis de um existente no genoma ou introduzir novo gene)

- ***Silenciamento de gene***

(reduzir a quantidade de mRNA e consequentemente de proteína)

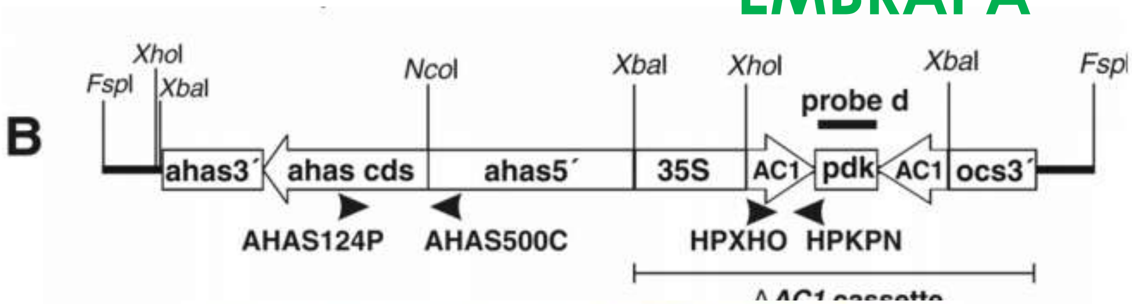
Estratégia para expressar um RNA mensageiro que forma uma estrutura de grampo (hairpin)

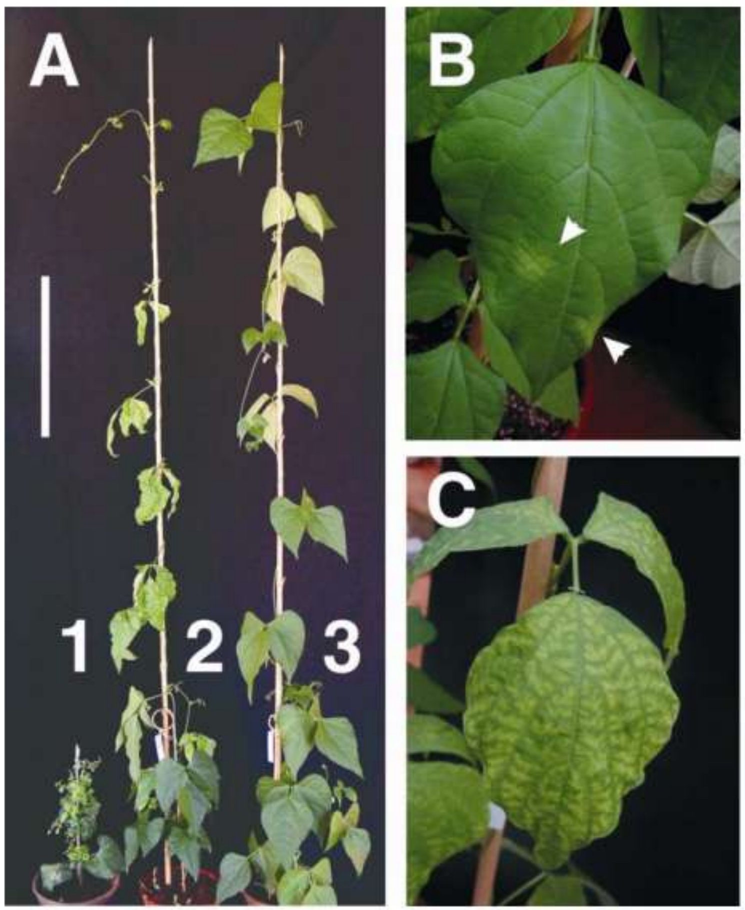




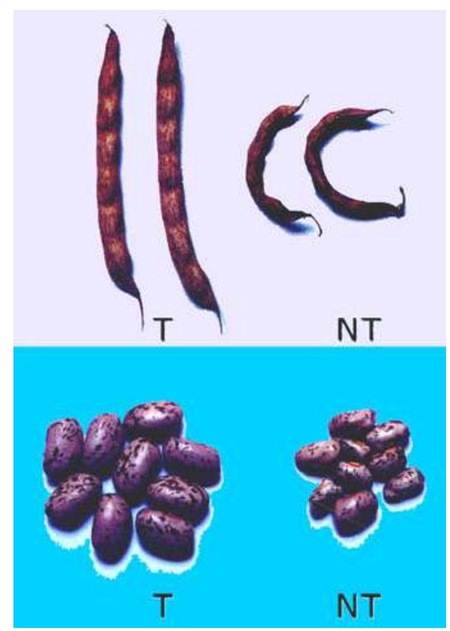
RNAm de gene alvo é DEGRADADO!!!!! E NÃO HÁ PRODUÇÃO DE PROTEÍNA!

RNAi-Mediated Resistance to Bean golden mosaic virus in Genetically Engineered Common Bean (*Phaseolus vulgaris*)-EMBRAPA

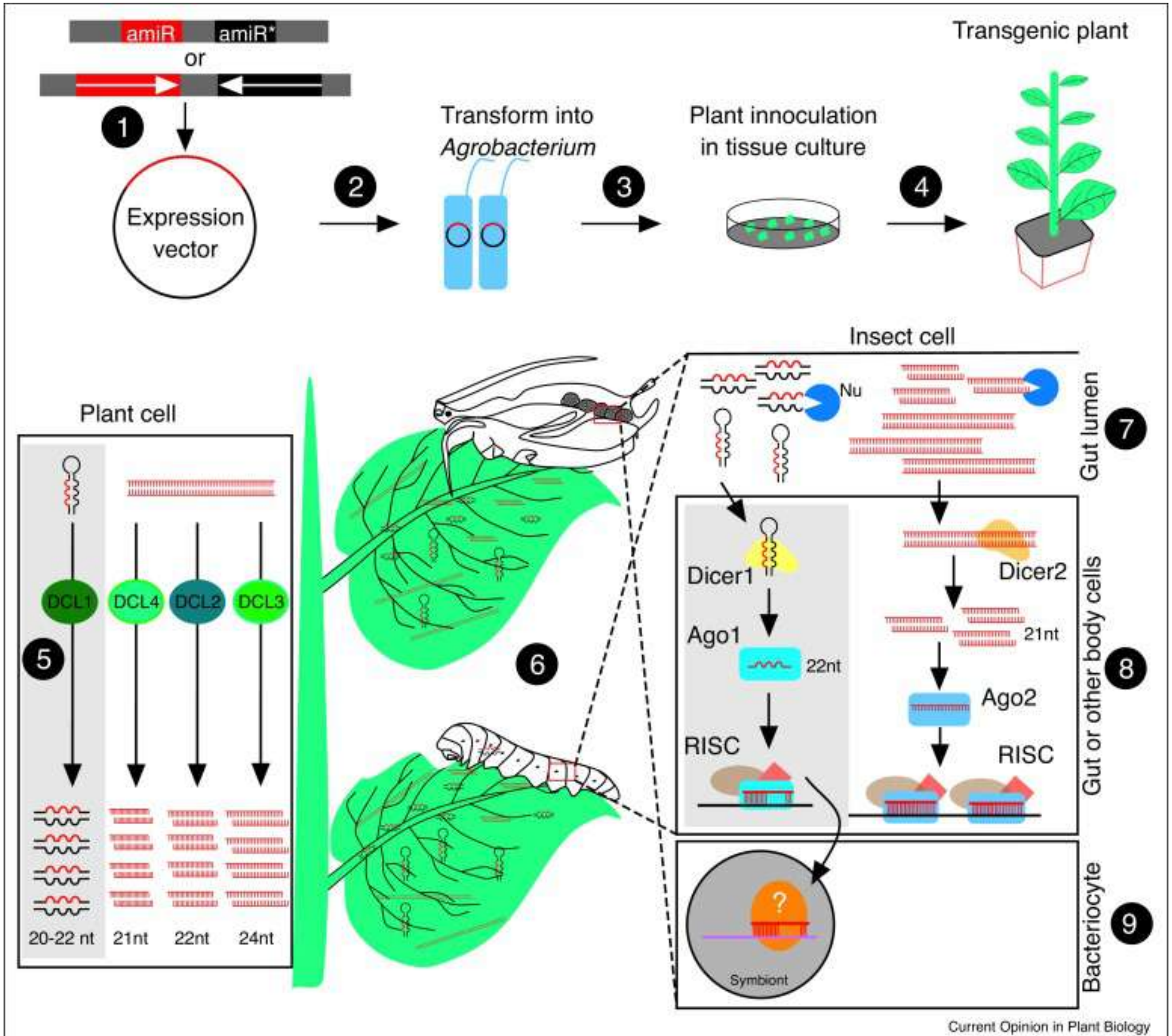




Expressa um mRNA em forma de grampo que da origem a um RNA dupla fita com um fragmento do gene da replicase viral (AC1)



Utilização de RNAi como resistência contra insetos- silenciando gene vital

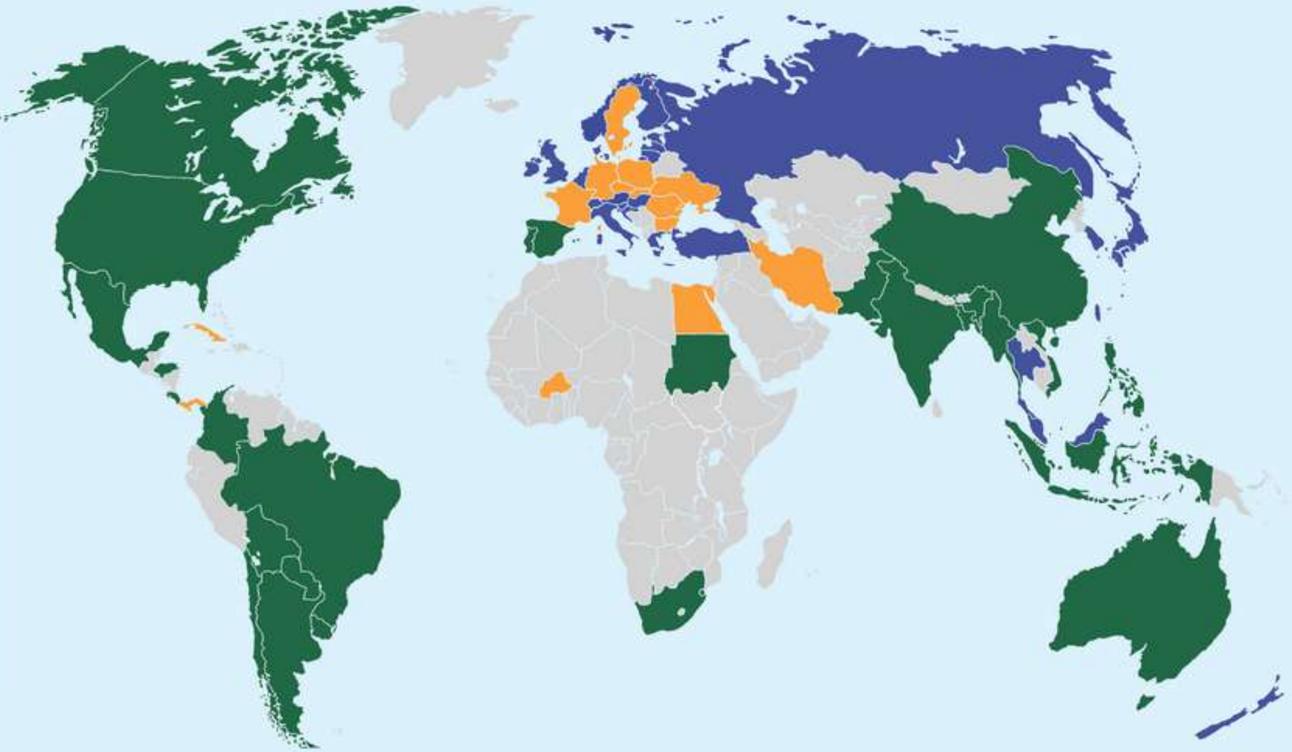


Chung, S. H., Feng, H., & Jander, G. (2021). Engineering pest tolerance through plant-mediated RNA interference. *Current opinion in plant biology*, *60*, 102029.

23 Years of Biotech Crops in the World

Since the first year of commercial planting of biotech crops in 1996, more than 70 countries from all over the world have either planted or imported biotech crops.

- The 6 founder biotech crop countries in 1996 are **USA, China, Argentina, Canada, Australia,** and **Mexico.**
- **Up to 17 million farmers** planted biotech crops in 2018, 95% is from developing countries.
- **26 countries** planted **191.7 million hectares** of biotech crops in 2018, a ~113-fold increase from 1.7 million hectares in 1996.
- In 2018, **26 countries planted** and **44 imported** biotech crops.



Countries planting biotech crops in 2018
(USA, Brazil, Argentina, Canada, India, Paraguay, China, Pakistan, South Africa, Uruguay, Bolivia, Australia, Philippines, Myanmar, Sudan, Mexico, Spain, Colombia, Vietnam, Honduras, Chile, Portugal, Bangladesh, Costa Rica, Indonesia, and eSwatini)

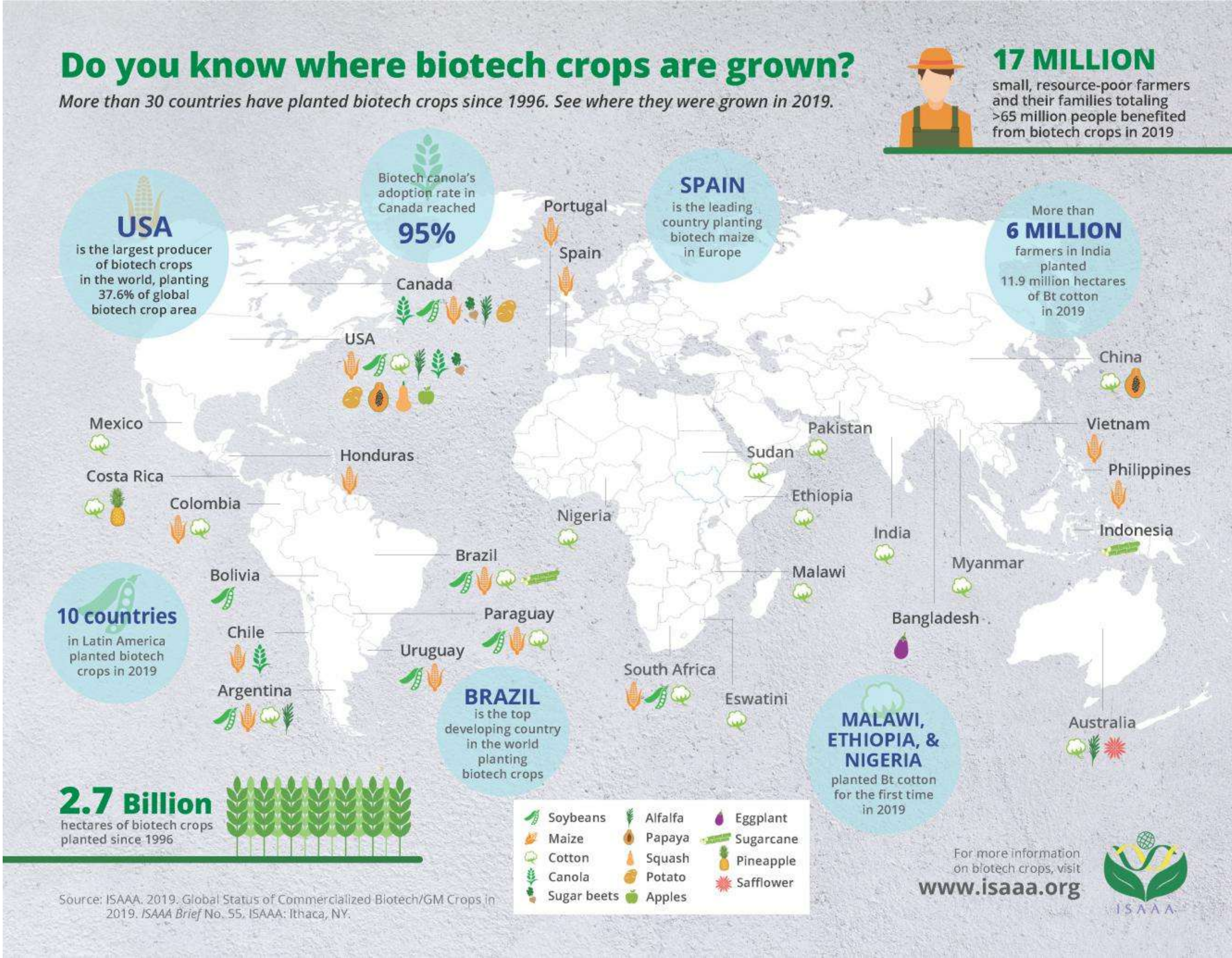
Countries that stopped planting, currently importing biotech crops
(Bulgaria, Burkina Faso, Czech Republic, Cuba, Egypt, France, Germany, Iran, Panama, Poland, Romania, Slovakia, Sweden, and Ukraine)

Countries not planting, but importing biotech crops
(Austria, Belgium, Croatia, Cyprus, Denmark, Estonia, Finland, Greece, Hungary, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Malaysia, Malta, Netherlands, New Zealand, Norway, Russian Federation, Singapore, Slovenia, South Korea, Switzerland, Taiwan, Thailand, Turkey, and United Kingdom)

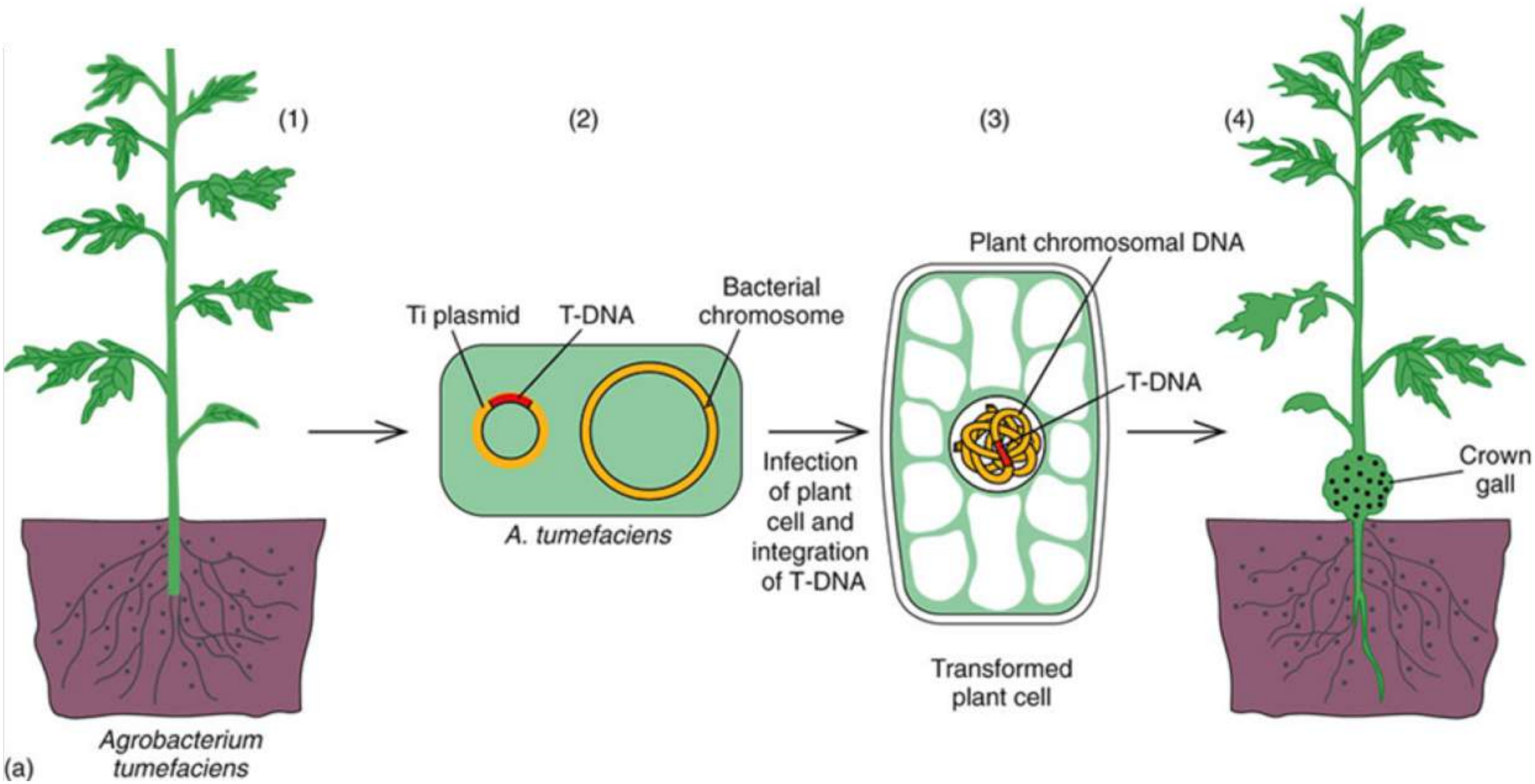
- ISAAA. 2018. Global Status of Commercialized Biotech/GM Crops in 2018. *ISAAA Brief* No. 54. ISAAA: Ithaca, NY.
- ISAAA GMO Approval Database (http://www.isaaa.org/gmapprovaldatabase/default.asp).

For more information on biotech crops, visit
www.isaaa.org

ISAAA


Do you know where biotech crops are grown?
More than 30 countries have planted biotech crops since 1996. See where they were grown in 2019.
17 MILLION
small, resource-poor farmers and their families totaling >65 million people benefited from biotech crops in 2019
USA
is the largest producer of biotech crops in the world, planting 37.6% of global biotech crop area
Biotech canola's adoption rate in Canada reached
95%
SPAIN
is the leading country planting biotech maize in Europe
More than
6 MILLION
farmers in India planted 11.9 million hectares of Bt cotton in 2019
Portugal
Spain
Canada
USA
China
Mexico
Honduras
Costa Rica
Colombia
Vietnam
Pakistan
Sudan
Philippines
Ethiopia
Nigeria
India
Indonesia
Brazil
Myanmar
Bolivia
Malawi
10 countries
in Latin America planted biotech crops in 2019
Paraguay
Bangladesh
Chile
Uruguay
South Africa
Argentina
Eswatini
BRAZIL
is the top developing country in the world planting biotech crops
MALAWI, ETHIOPIA, & NIGERIA
planted Bt cotton for the first time in 2019
Australia
2.7 Billion
hectares of biotech crops planted since 1996
Soybeans
Maize
Cotton
Canola
Sugar beets
Alfalfa
Papaya
Squash
Potato
Apples
Eggplant
Sugarcane
Pineapple
Safflower
For more information on biotech crops, visit
www.isaaa.org
ISAAA
Source: ISAAA. 2019. Global Status of Commercialized Biotech/GM Crops in 2019. ISAAA Brief No. 55. ISAAA: Ithaca, NY.

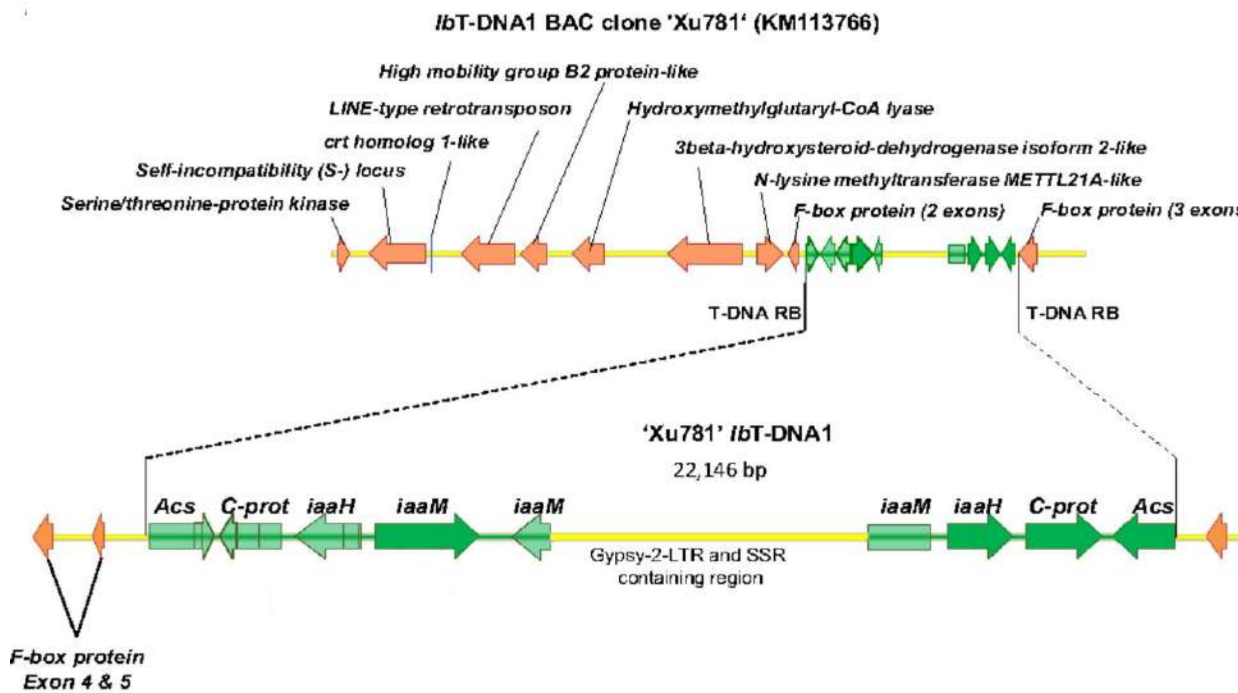
Transferência horizontal de genes



A. tumefaciens

291 acessos testados

iaa = biossíntese auxina
acs = biossíntese opina
C-prot = função desconhecida

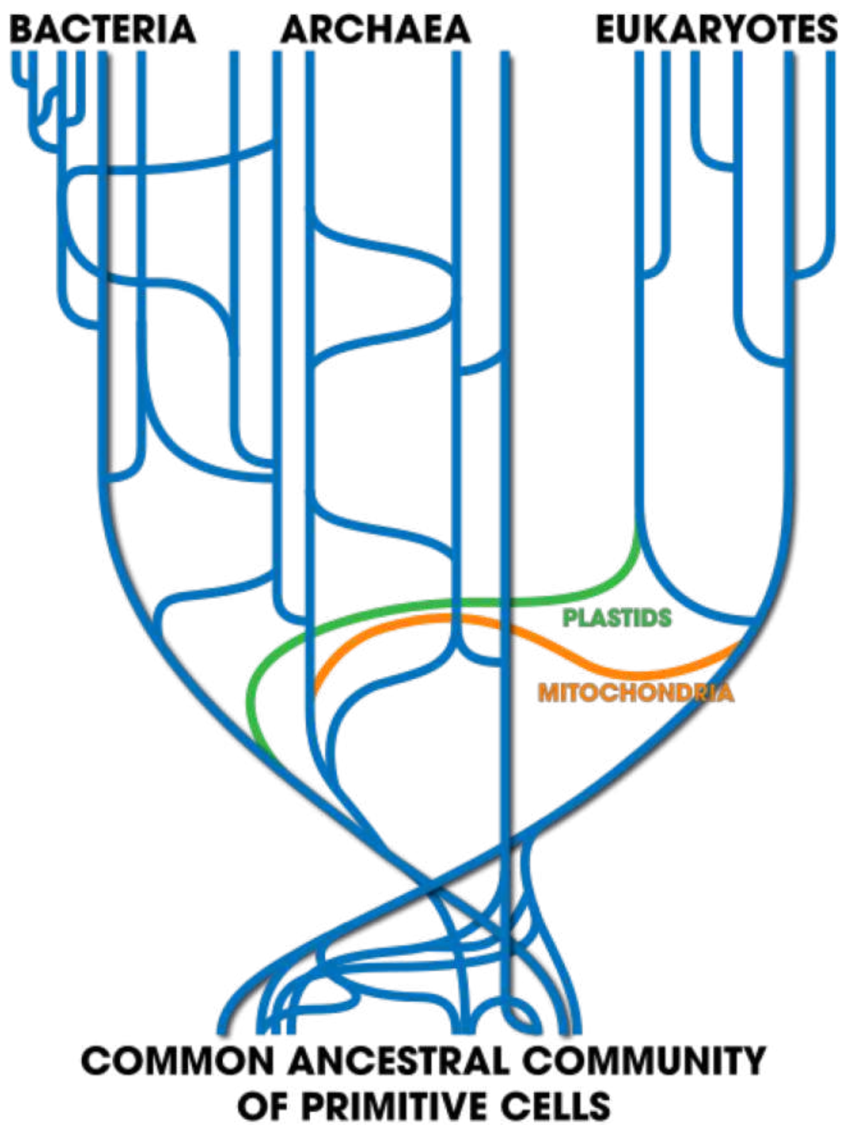


Adaptado de Kyndt, T., Quispe, D., Zhai, H., Jarret, R., Ghislain, M., Liu, Q., ... & Kreuze, J. F. (2015). The genome of cultivated sweet potato contains Agrobacterium T-DNAs with expressed genes: an example of a naturally transgenic food crop. Proceedings of the National Academy of Sciences, 112(18), 5844-5849.

Transferência horizontal de genes

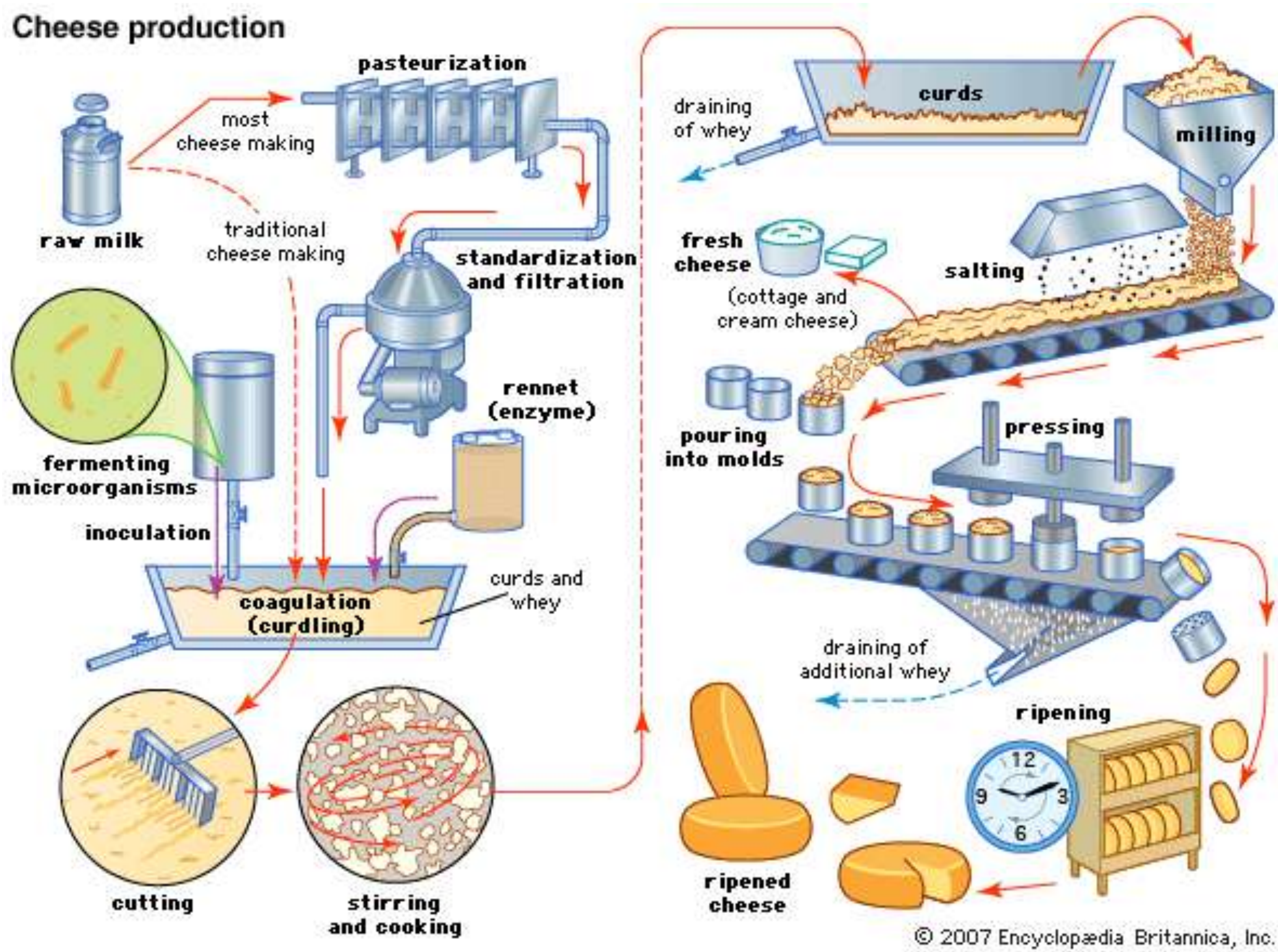
Há outros exemplos?

Transferência lateral de genes

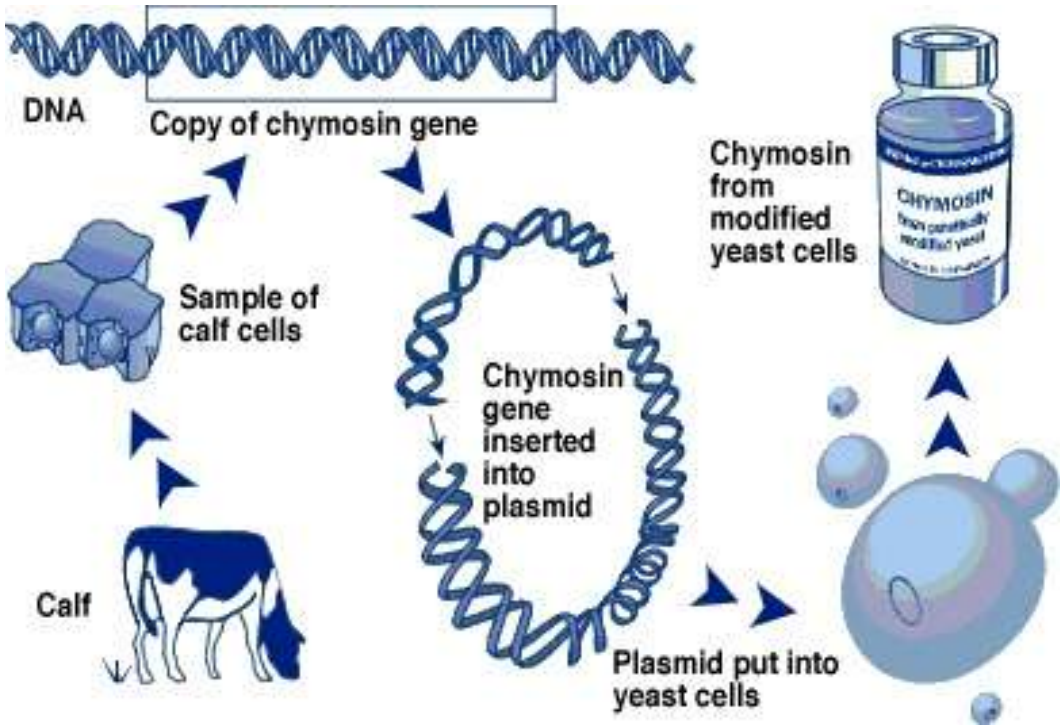


Há transgênicos em outras áreas?

Alimentação: quimosina



Alimentação: quimosina



http://www.ncbe.reading.ac.uk/ncbe/gmfood/chymosin.

Saúde: vacinas, hormônios

Tabela 1 – Principais contribuições da biotecnologia no desenvolvimento de vacinas

Tipo vacinal	Estratégia biotecnológica	Vacinas
Vacinas de subunidades	Produção de proteínas recombinantes em sistemas heterólogos	Hepatite B, pertússis acelular, HPV
Patógenos atenuados bivalentes	Manipulação genética para inserção de genes que codifiquem antígenos	Dengue,* BCG,* Salmonella Typhi,* Adenovírus*
Vacinas de DNA	Imunização com plasmídeos recombinantes	Vacina contra melanoma#

* Vacinas ainda não disponíveis para uso em humanos; # vacina para uso em cães.

Bactérias transgênicas (E. coli)

Bactérias transgênicas (E. coli)

Produtos de limpeza

As enzimas auxiliam na remoção de manchas, além de ser um produto natural e 100% biodegradável (i.e. Novozymes).

Hormotrop®
somatropina
12 UI
VENDA SOB PRESCRIÇÃO MÉDICA
Bergamo
Humulin®
N
INSULINA HUMANA
RECOMBINANTE
ISÓFANA
M.B.
100 UI/mL
Lilly
CEREJA E LARANJA + HORTELÃ
Chiclets®
ADAMS
Dr.Oetker
Gelatina
Diet
Cereja
mabel
MARIA
Gomes da Costa
Sardinhas
com Óleo
Marilan
Cream
Cracker
1870
AMSTEL
LAGER
Liza
SOJA
Remove as
Manchas
+Difíceis
de primeira
OMO
Multiação
1kg
Milho para
Canjica
WALLY
vacina quadrivalente recombinante contra papilomavírus
humano (tipos 6, 11, 16 e 18)
USO ADULTO E PEDIÁTRICO (ENTRE 9 E 26 ANOS)
Uso Intramuscular
VENDA SOB PRESCRIÇÃO MÉDICA
MSD
200 g
MAIZENA
DURYEA®
AMIDO DE MILHO
Faz mais do que você imagina!
Le Pets
Bifinhos
Sabor
Carne
30g
Doritos
QUEIJO
NACHO

- **Conselho de Informações sobre Biotecnologia (http://www.cib.org.br)**

(info geral)

- **Comissão Técnica Nacional de Biossegurança (http://www.ctnbio.gov.br)**

(legislação)

- **International Service for the Adquisition of Agri-Biotech Applications (http://www.isaaa.org)**

(números globais)

- **Center of Environmenta Risk Assessment (www.cera-gmc.org)**

(detalhes dos eventos)

https://gmoanswers.com/

https://geneticliteracyproject.org/