Geneticky modifikované organizmy

(Nielen v potravinách)

Mgr. Peter Lenárt Ph.D.

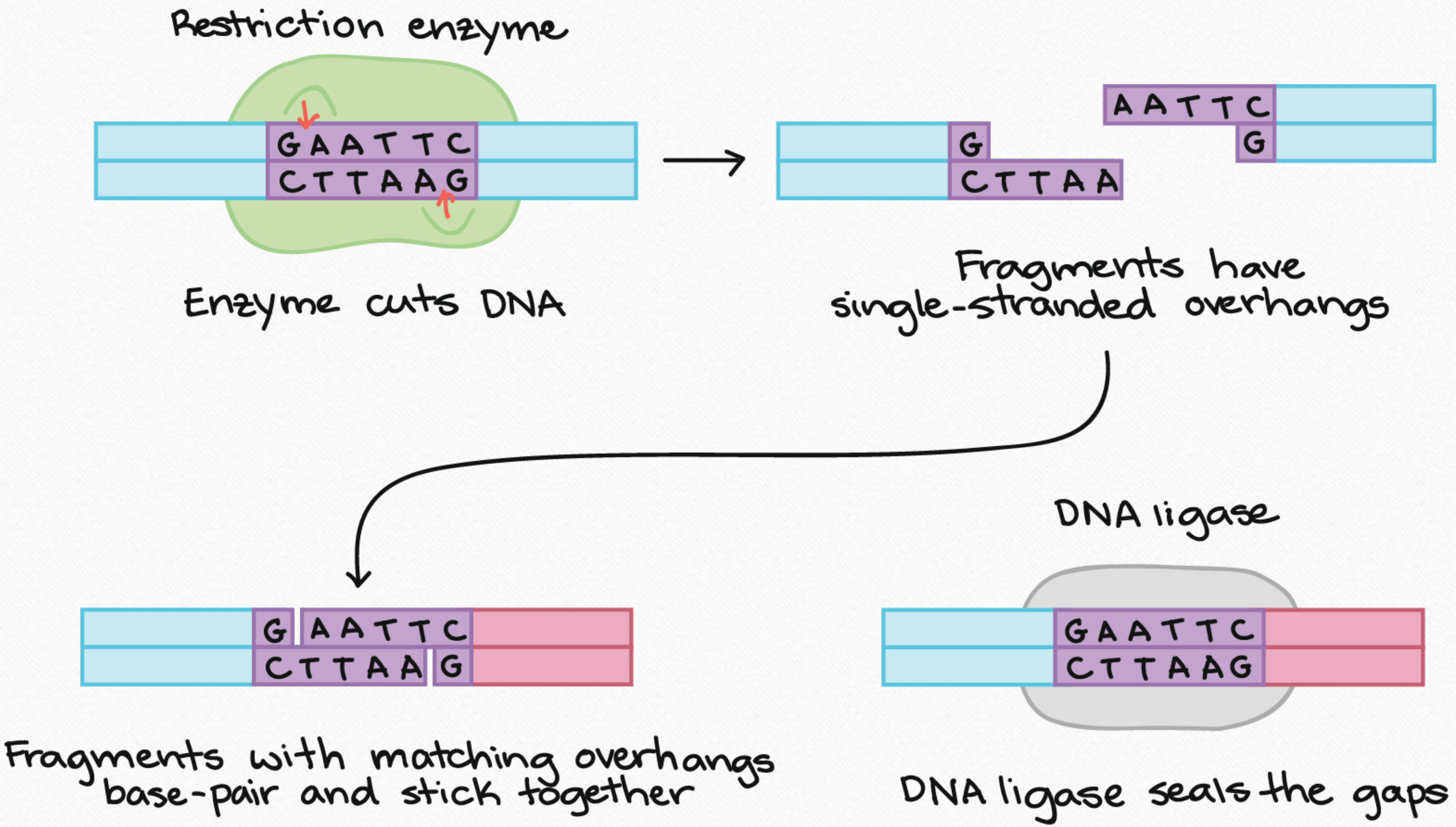
Geneticky modifikovaný organizmus

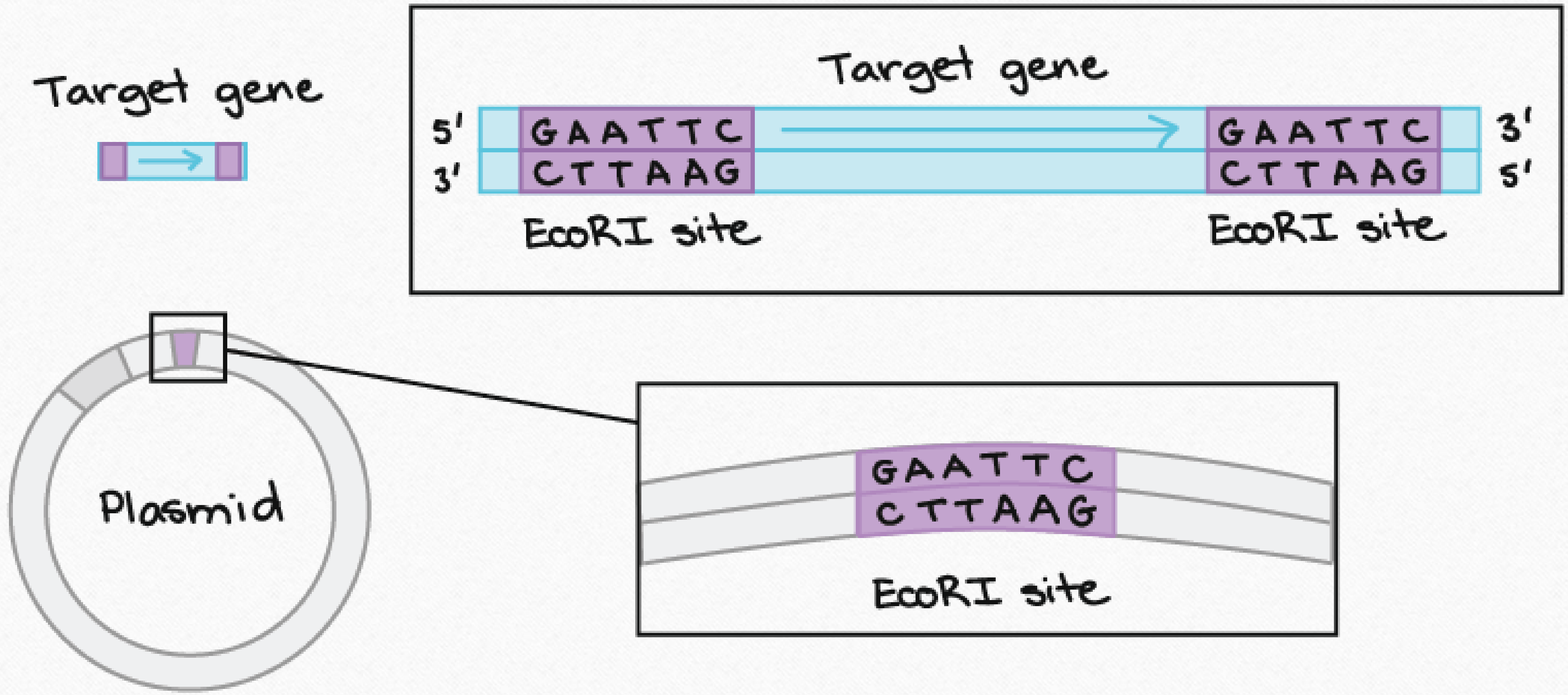
- Organizmus, ktorého genetický materiál bol upravený pomocou metód génového inžinierstva

Niekedy sa vyčleňujú takzvané transgénne organizmy :

- Organizmy, do ktorých bola vložená genetická informácia nepríbuzného organizmu

História a využitie


Restriction enzyme
GAATTC
CTTAAG
Enzyme cuts DNA
G
CTTAA
AATTC
G
Fragments have
single-stranded overhangs
G AATTC
CTTAA G
Fragments with matching overhangs
base-pair and stick together
DNA ligase
GAATTC
CTTAAG
DNA ligase seals the gaps


Target gene
Target gene
5′
3′
GAATTC
CTTAAG
GAATTC
CTTAAG
3′
5′
EcoRI site
EcoRI site
Plasmid
GAATTC
CTTAAG
EcoRI site

Prvé aplikácie

- Ľudský inzulín bol prvým liečivom vyrábaným pomocou genetického inžinierstva
  - Úspešná výroba od roku 1978 (FDA schválila v 1982)
- Nasledovala rada ďalších medicínskych aplikácií ako napr. výroba rekombinantného ľudského rastového hormónu (1981) či príprava prvých rekombinantných zvieracích vakcín (1982)

1951:
10,000 POUNDS OF PIG PANCREASES MAKE 1 POUND OF INSULIN

TODAY:
GENETICALLY ENGINEERED BACTERIA PRODUCE ANIMAL-FREE INSULIN

Ojedinelé aplikácie?

- V roku 2015 bolo okolo 400 liečiv vyrábaných pomocou DNA rekombinantných technológií

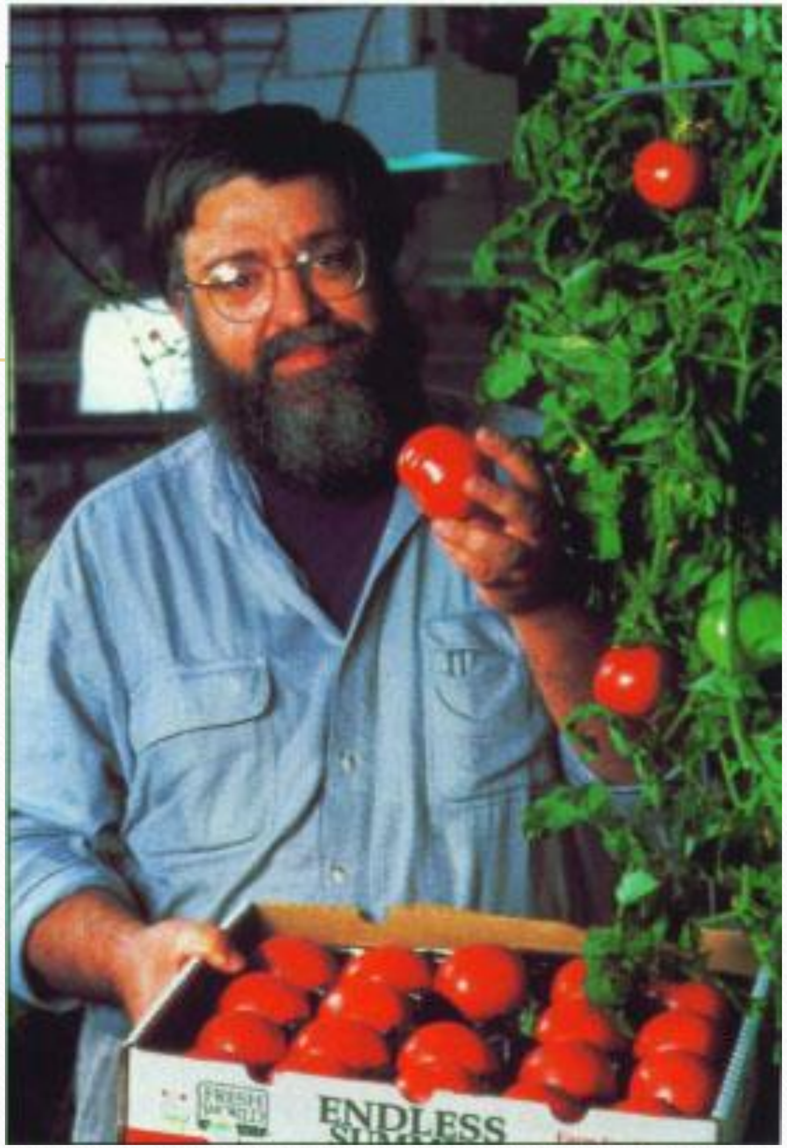
GMO baktérie neprodukujú len lieky

- Medzi ďalšie využitia patrí produkcia:
  - syrov
  - pracích prostriedkov
  - biosenzorov
  - papiera
  - textilu
  - piva
  - a ďalších

Geneticky modifikované potraviny

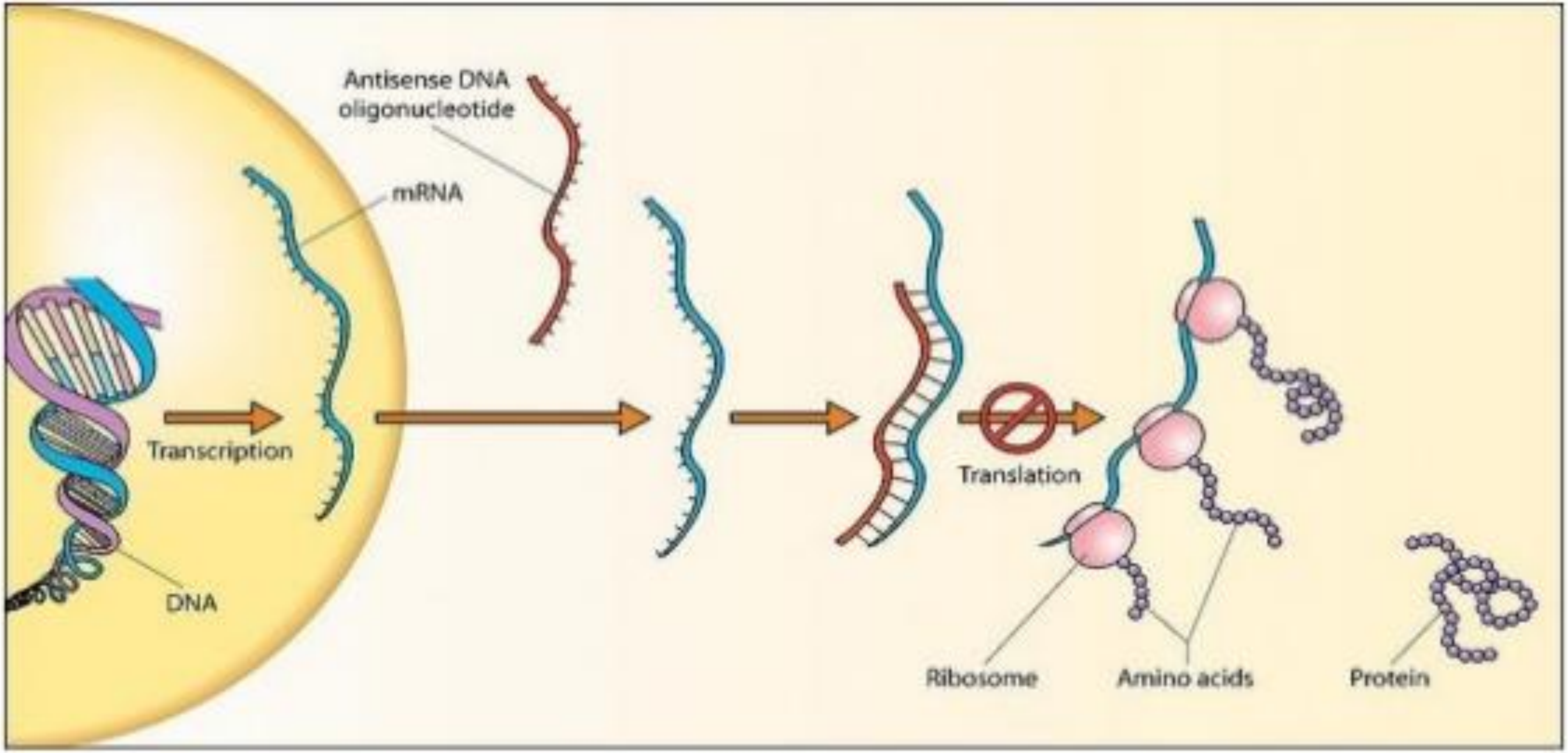
Flavr Savr Rajče

- Prvá geneticky modifikovaná potravina schválená FDA (1994)
- Rajčata s predĺženým dozrievaním – dlhšie prežijú skladovanie a uchovávajú si prirodzenú chuť a farbu
- S počiatku veľký komerčný záujem, ale pre vysoké náklady na produkciu nikdy nešlo o ziskový produkt
- V roku 1997 bola v USA výroba zastavená



Flavr Savr Rajče

- Rajčata produkujú enzým polygalakturonidáza, ktorý rozkladá pektín v bunečnej stene a tým spôsobuje „mäknutie rajčat“.
- Do rajčat sa vložila druhá kópia génu kódujúceho polygalakturonidázu, avšak sekvencia génu bola „otočená naopak“


Antisense DNA
oligonucleotide
mRNA
Transcription
DNA
Translation
Ribosome
Amino acids
Protein

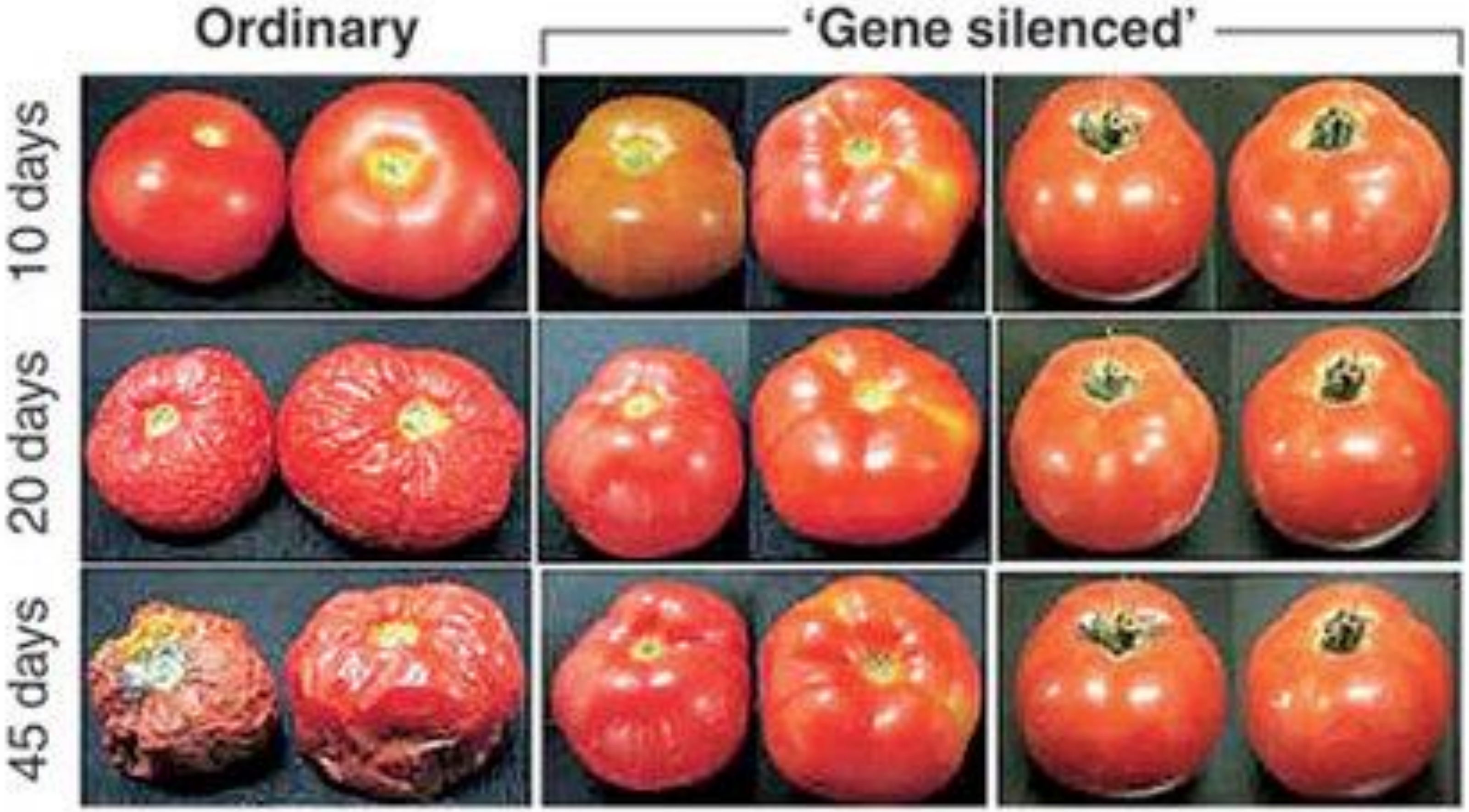


Image shows three sets of tomatoes. The ordinary control tomatoes (extreme left) soften and shrivel up, while texture of gene-silenced tomatoes remains intact for up to 45 days.

Photo credit: Asis Datta, Subhra Chakraborty, National Institute of Plant Genome Research, New Delhi

Miera využívania GMO plodín v poľnohospodárstve

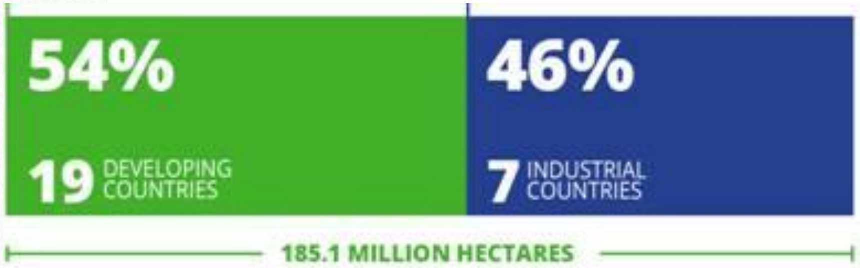


FIGURE 2.
DISTRIBUTION OF BIOTECH CROPS IN DEVELOPING AND INDUSTRIAL COUNTRIES IN 2016

Source: ISAAA, 2016

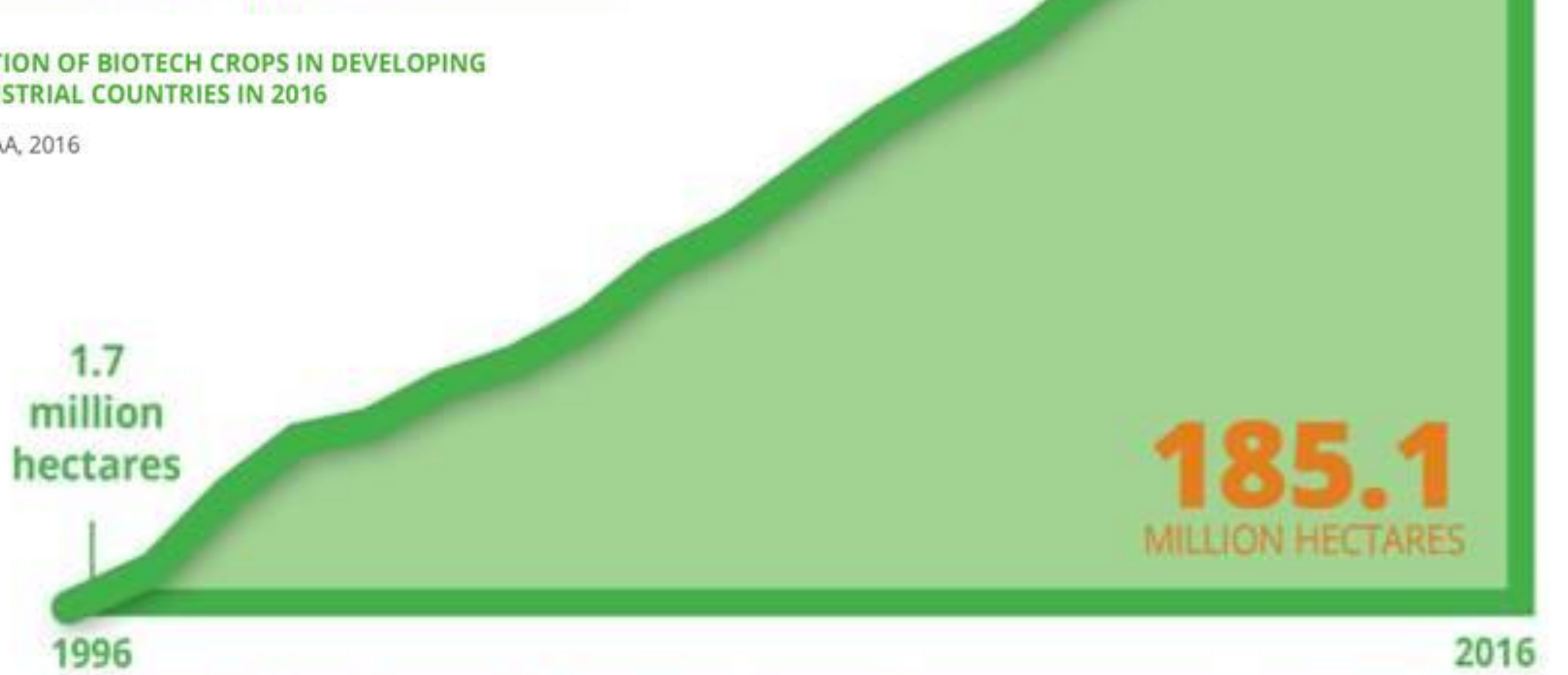


FIGURE 1. GLOBAL AREA OF BIOTECH CROPS, 1996 TO 2016 (MILLION HECTARES).

Source: ISAAA, 2016

26 countries planted 185.1 million hectares (457.4 million acres) of biotech crops in 2016, the 21st year of global commercialization of biotech crops

19 DEVELOPING COUNTRIES

7 INDUSTRIAL COUNTRIES

TOP 5 COUNTRIES GROWING BIOTECH CROPS IN 2016 (MILLION HECTARES)

USA	72.9
Brazil	49.1
Argentina	23.8
Canada	11.6
India	10.8

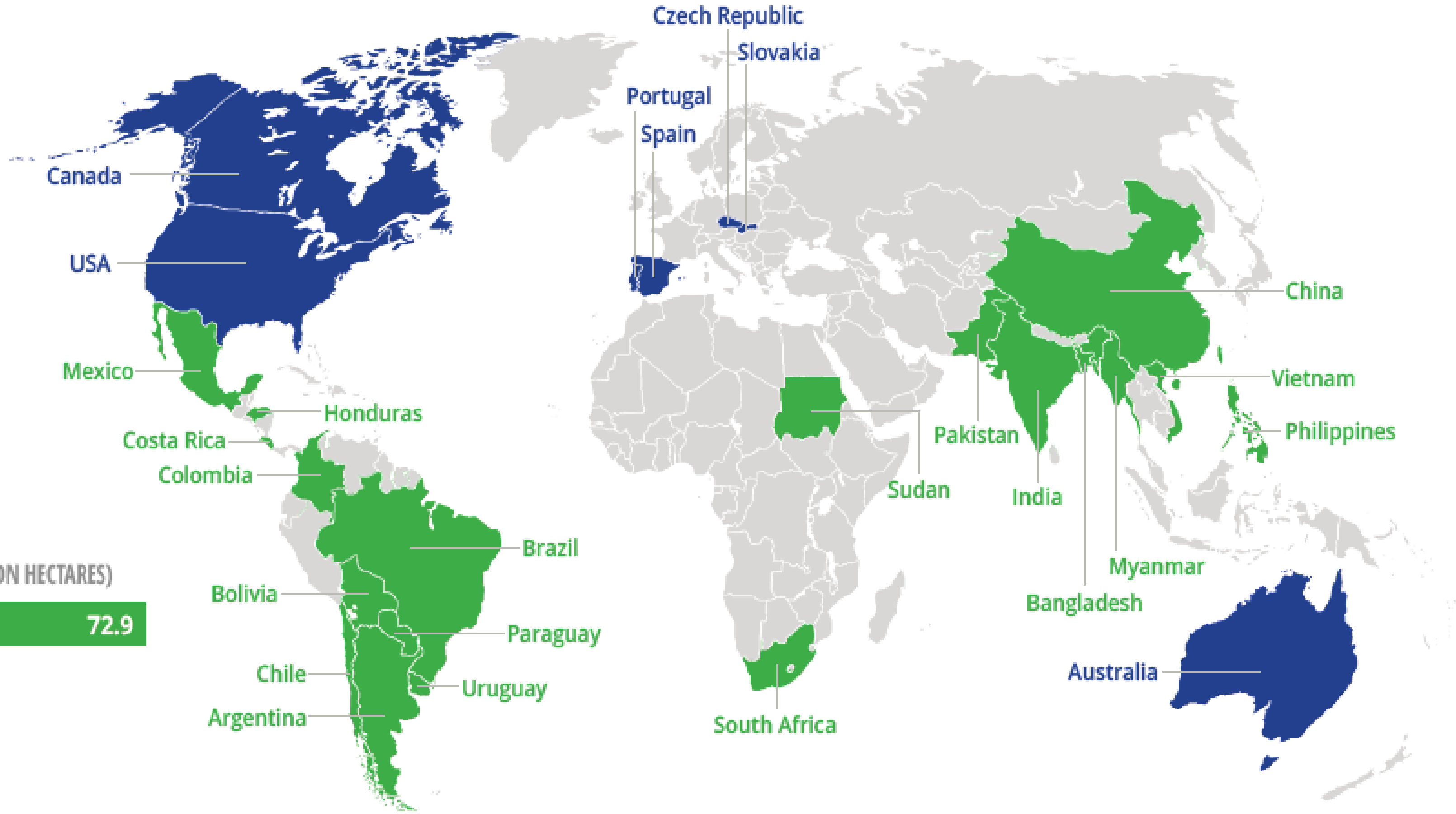
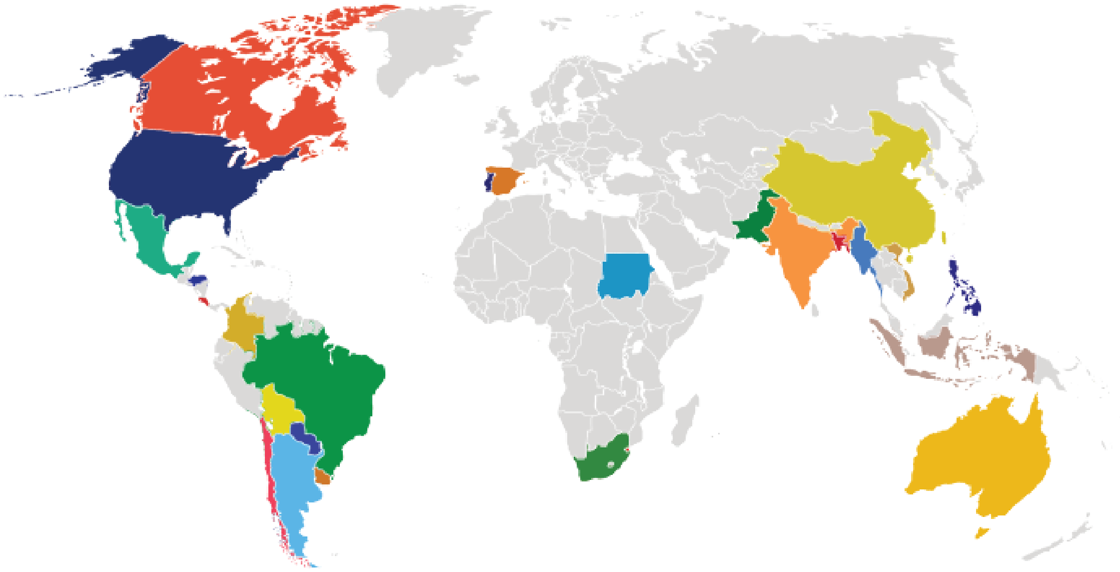
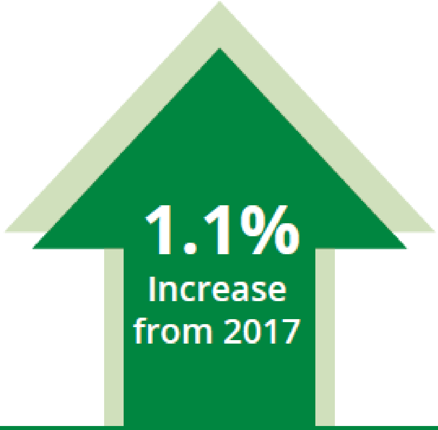


Figure 2. Global Area (Million Hectares) of Biotech Crops, 1996 to 2018, by Country, Mega-Countries, and for the Top Ten Countries



26 countries which have adopted biotech crops



In 2018, global area of biotech crops was 191.7 million hectares, representing an increase of 1.1% from 2017, equivalent to 1.9 million hectares.

Source: ISAAA, 2018

50,000 hectares, or more

1.	*USA*	75.0 million
2.	Brazil*	51.3 million
3.	Argentina*	23.9 million
4.	*Canada*	12.7 million
5.	India*	11.6 million
6.	Paraguay*	3.8 million
7.	China*	2.9 million
8	Pakistan*	2.8 million
9.	South Africa*	2.7 million
10.	Uruguay*	1.3 million
11.	Bolivia*	1.3 million
12.	*Australia*	0.8 million
13.	Philippines*	0.6 million
14.	Myanmar*	0.3 million
15.	Sudan*	0.2 million
16.	Mexico*	0.2 million
17.	*Spain*	0.1 million
18.	Colombia*	0.1 million

Less than 50,000 hectares

Vietnam*	Bangladesh*
Honduras*	Costa Rica*
Chile*	Indonesia*
Portugal	eSwatini*

** Developing countries*

Poradie	Krajina	2017 (miliónov hektárov)	2018 (miliónov hektárov)
1	USA	75.0	75
2	Brazília	50.2	51.3
3	Argentina	23.6	23.9
4	Canada	13.1	12.7
5	India	11.4	11.6
6	Paraguay	3.0	3.8
7	Pakistan	3.0	2.8
8	China	2.8	2.9
9	South Africa	2.7	2.7
10	Bolívia	1.3	1.3

Zdroj: ISAAA

CROP TRAITS UNDER VARIOUS STAGES OF RESEARCH IN AFRICA IN 2017

Kenya

Crop	Trait
Maize	Drought tolerance: Water Efficient Maize for Africa (WEMA)
	WEMA Insect resistance (Bt maize)
	Stacked maize event for Bt and Drought
Cotton	Insect resistance
Gypsophila flower	Pink Colouration of Petals
Cassava	Cassava Brown Streak Disease (CBSD)
	Cassava Mosaic Disease (CMD)
Sweet potato	Resistance to Sweet potato virus disease
Banana	Banana bacterial -Xanthomonas Wilt (BXW) resistance
Sorghum (ABS)	Biofortification

Zdroj: ISAAA

Nigeria

- **Cowpea** — Insect resistant to Maruca pest
- **Sorghum (ABS)** — Biofortification
- **Rice** — Nitrogen use ,Water efficiency and salt tolerant (NUWEST) Rice
- **Maize** — Insect resistance Bt + Herbicide tolerant Ht corn
- **Cotton** — Insect resistance
- **Cassava** — Delayed postharvest starch deterioration

Ethiopia

- **Cotton** — Insect resistance

Sudan

- **Cotton** — Insect resistance

Uganda

- **Maize** — Drought tolerance and Insect resistance stacked events (WEMA)
- **Banana** — Banana bacterial -Xanthomonas Wilt (BXW) resistance
  - Banana parasitic nematode resistance
  - Biofortification
- **Cassava** — Cassava brown streak Disease (CBSV) resistance
  - Cassava Mosaic Disease
- **Rice** — Nitrogen Use/Water Efficiency and salt tolerant
- **Potato** — Late blight Disease resistance

Tanzania

- **Maize** — Drought tolerance; Stacked – Bt/DT (WEMA)

Malawi

- **Cotton** — Insect resistance
- **Banana** — Bunchytop virus resistance
- **Cowpea** — Insect resistance
- **Banana plantain** — Bunchytop virus resistance

Zdroj: ISAAA

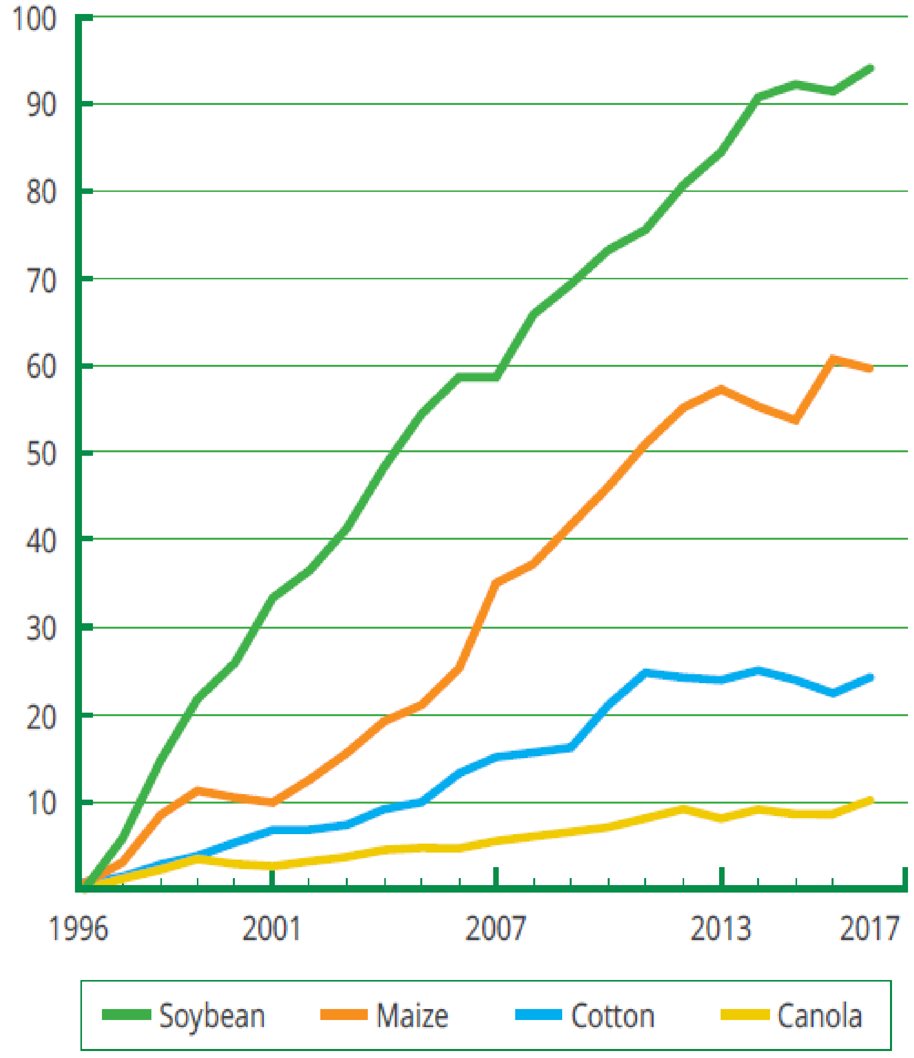


Figure 16. Global Area of Biotech Crops, 1996 to 2017: by Crop (Million Hectares)

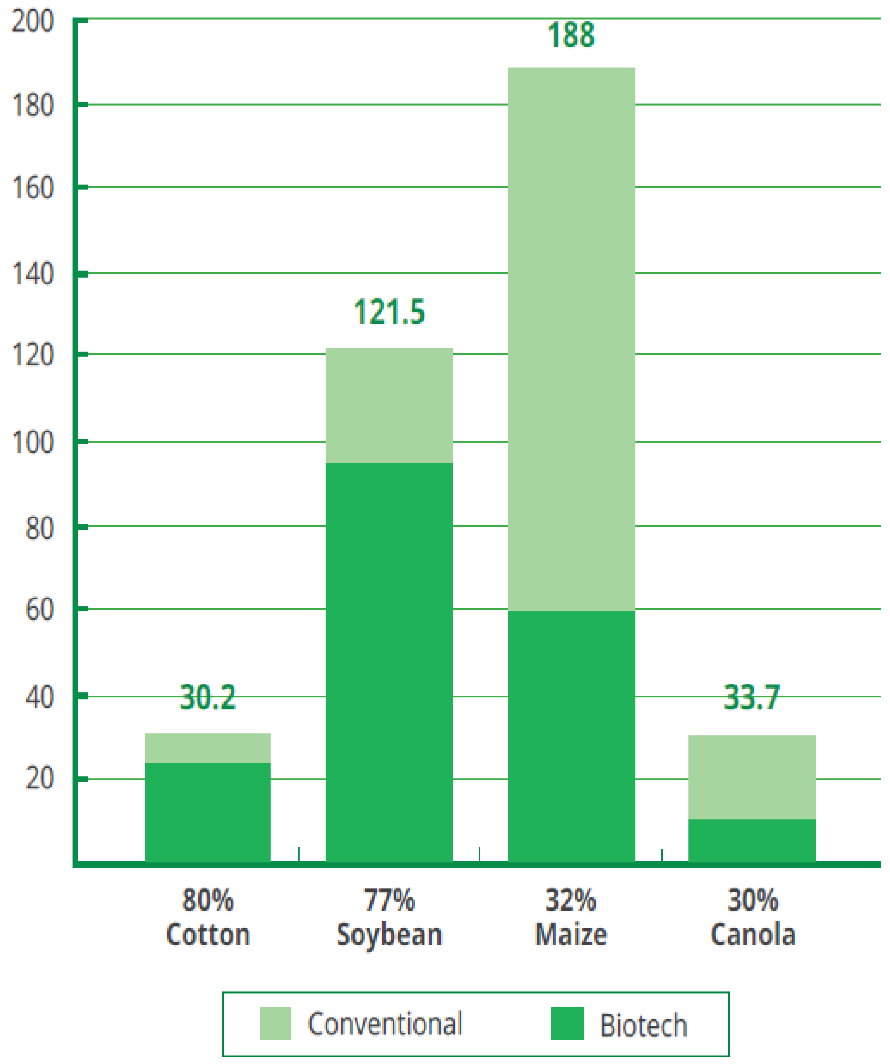
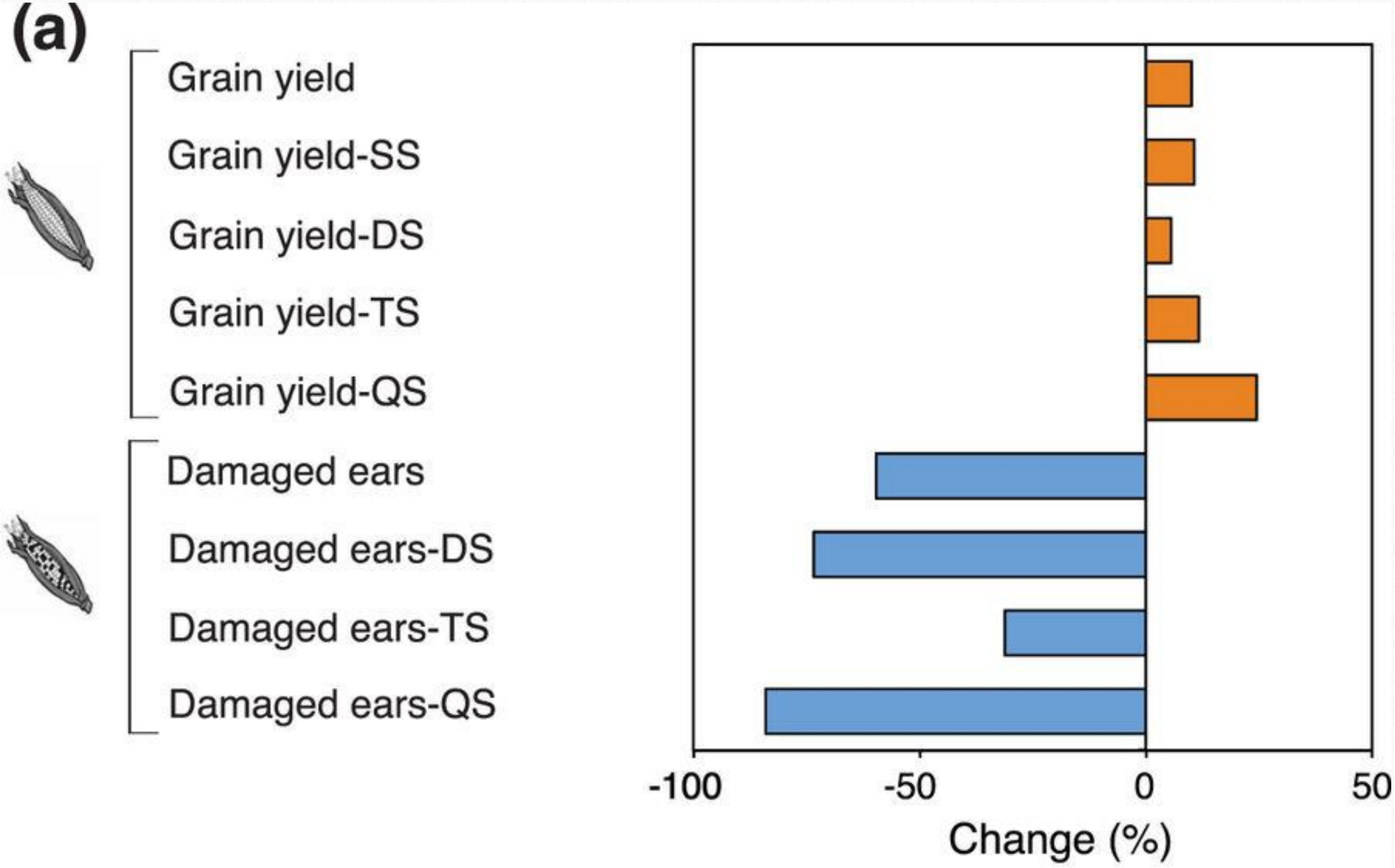
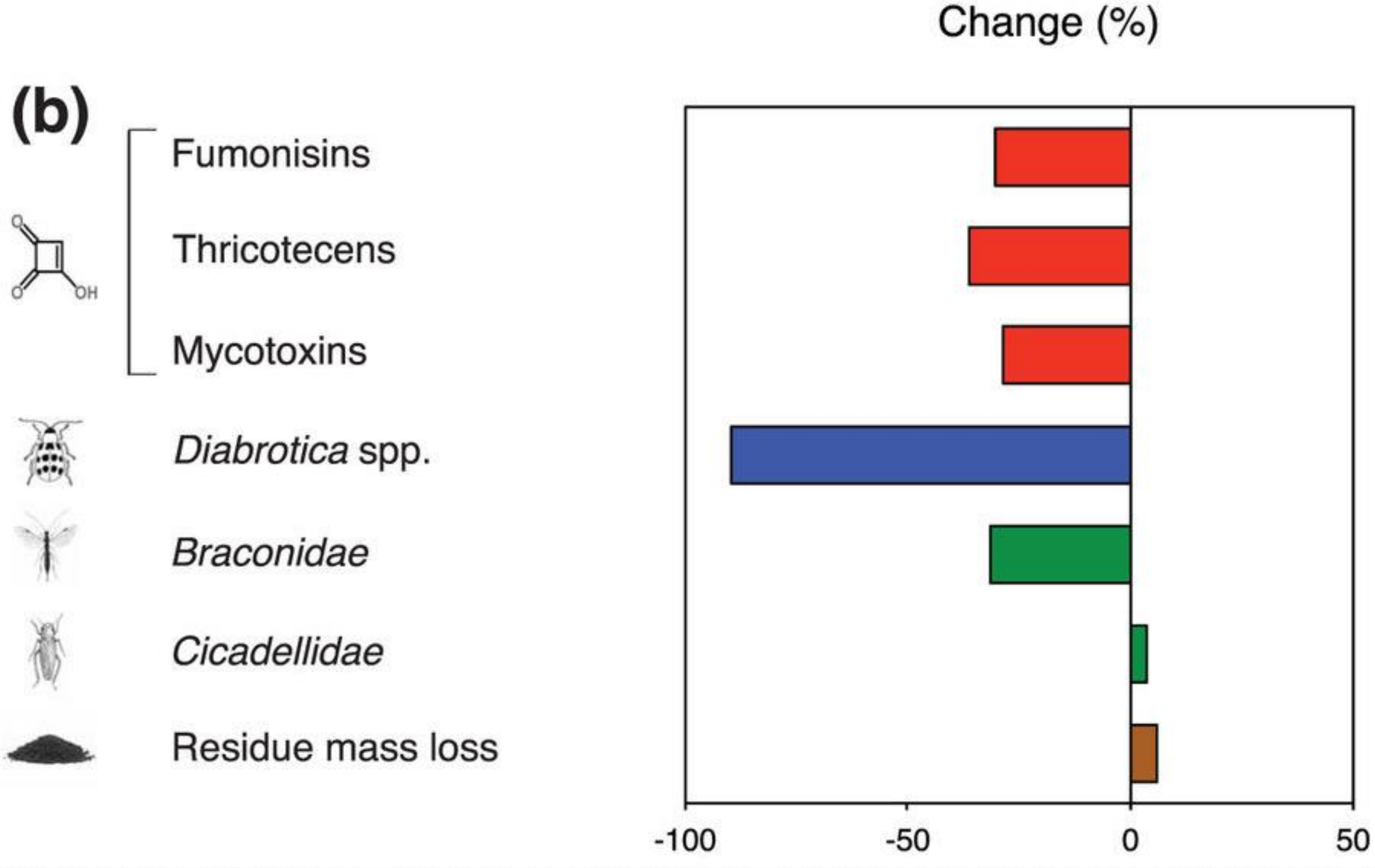


Figure 17. Global Adoption Rates (%) for Principal Biotech Crops, 2017 (Million Hectares)

Efektívnosť GMO plodín



Pellegrino et al., 2018



Pellegrino et al., 2018

- Používanie geneticky modifikovanej ryže viedlo k redukcií používania herbicídov o 10.1% a insekticídov o 45.2%
- Používanie GMO rastlín tiež viedlo k výraznému zníženiu produkcie skleníkových plynov, ktoré bolo len v roku 2011 ekvivalentné odstráneniu viac ako 10 miliónov áut (Brookes and Barfoot 2011)
- Ekonomický prínos pestovania GMO bol len v roku 2012 18.8 miliardy dolárov
- GMO tiež výrazne zdvihli svetovú produkciu sóje a kukurice (Brookes and Barfoot 2012).

Bezpečnosť

- GMO potraviny sú najprísnejšie regulovaným typom potraviny na svete
- Desiatky nezávislých vedeckých panelov vyhlásilo, že transgénne potraviny sú rovnako bezpečné, ako potraviny vyšľachtené iným spôsobom.
- K tomuto záveru dospela aj desaťročná štúdia financovaná európskou komisiou (voľne dostupné pod názvom „A decade of EU-funded GMO research - European Commission“)
- Patogény vyskytujúce sa v potravinách predstavujú neporovnateľne väčšie riziko ako GMO
    - V roku 2012 americké centrum pre kontrolu nemocí (CDC) v Atlante registrovalo vyše 128 000 prípadov hospitalizácie a 3 000 úmrtí v následku patogénov vyskytujúcich sa v potravinách. Na druhú stranu za vyše 20 rokov komerčného využitia GMO plodín v USA nebol zaregistrovaný jediný súvisiaci prípad úmrtia.

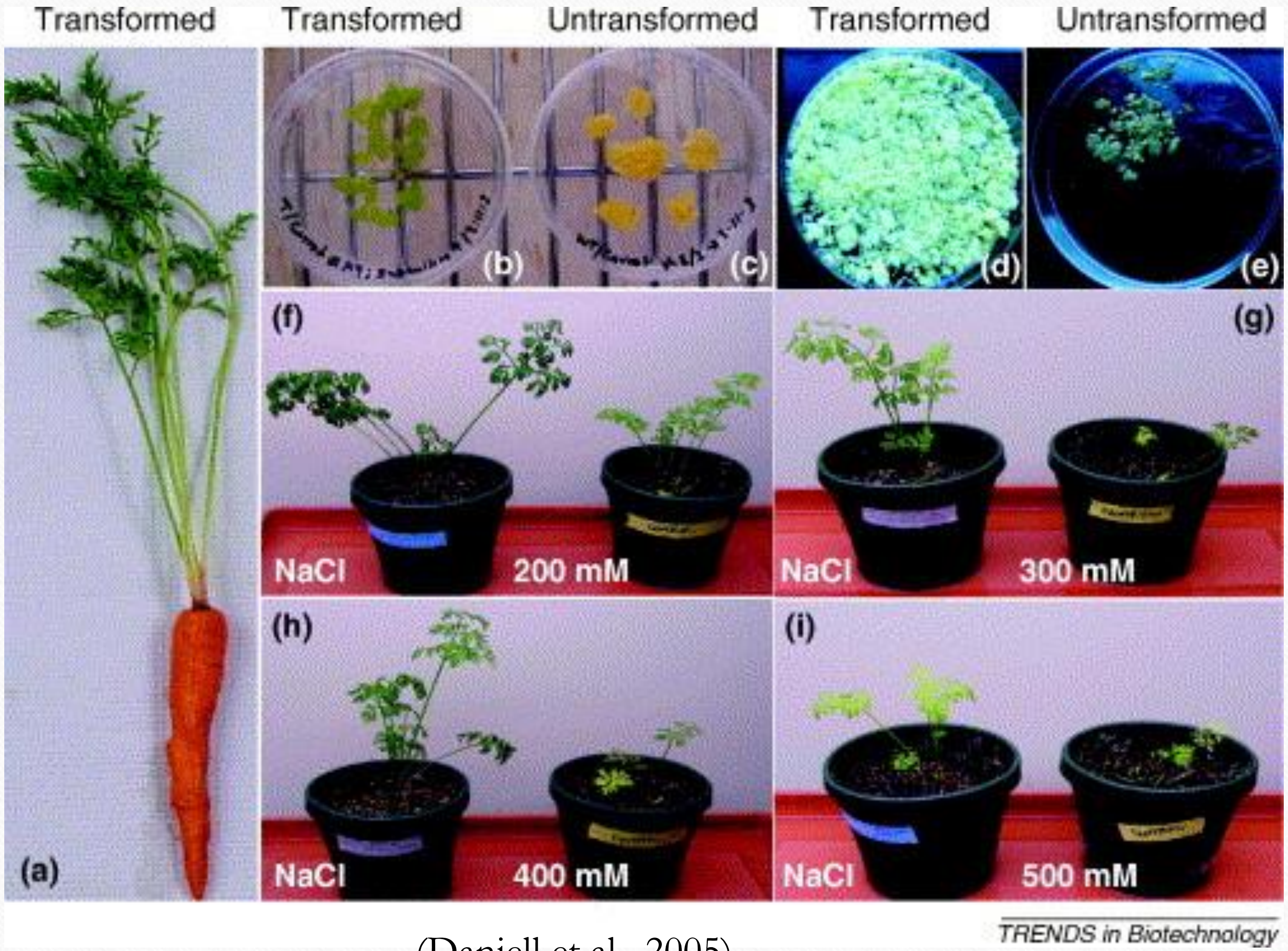
Typy GM plodín

Ciele genetických modifikácií

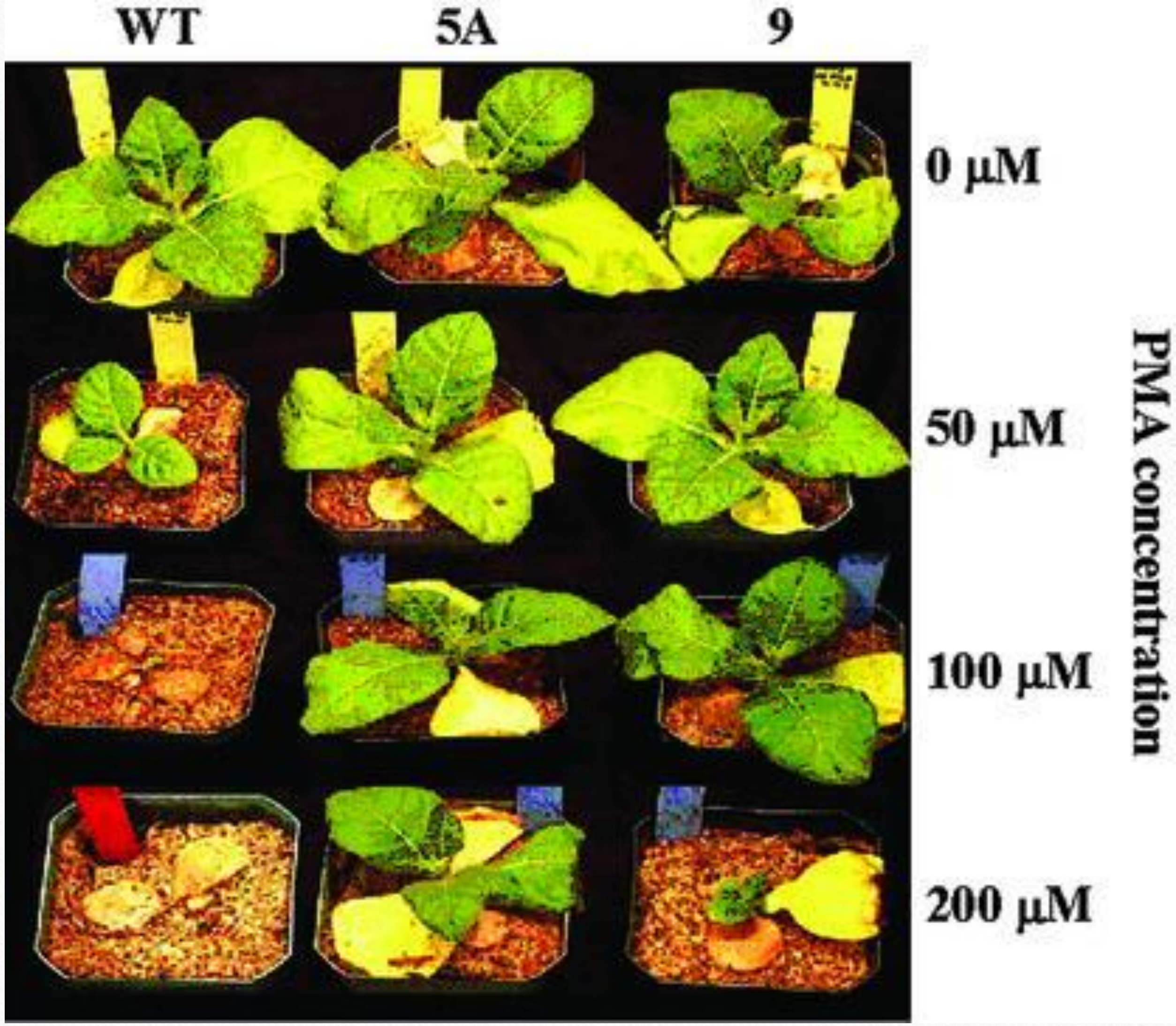
1. Generácia GM plodín
   a) Rezistencia k herbicídom
   b) Rezistencia voči vírusom, baktériám a hmyzím škodcom
2. Generácia GM plodín
   a) Zvýšenie nutričnej hodnoty
   b) Zlepšenie chuti, kvality a trvanlivosti potravín
   c) Modifikácie organizmu pre prežitie v extrémnych podmienkach
   d) Získanie obnoviteľných a ekologických zdrojov pre chemickú výrobu
   e) Zvýšenie mechanickej stability proti škodám pri transporte a skladovaní

Ciele genetických modifikácií

3. Generácia GM plodín
   a) nové typy rastlín



(Daniell et al,. 2005)



(Ruiz et al., 2003)

PMA = phenylmercuric acetate

Príklady GMO potravín

Bt-kukurica

- Bacillus thuringiensis produkuje protein Cry (δ-endotoxin), ktorý je selektívne škodlivý pre škodcov Lepidoptera, Diptera, Coleoptera.
- Bt-insekticídy sú obľúbené medzi organickými farmármi, pretože sú to „prírodne insekticídy“
- Bt-kukurica bola vyrobená inzerciou génu cry, vďaka čomu si rastlina sama vyrába Cry proteín, čo výrazne znižuje potrebu používania insekticídov

Kontrola Bt-kukurica

Bt-kukurica Kontrola Kontrola

Zlatá rýža

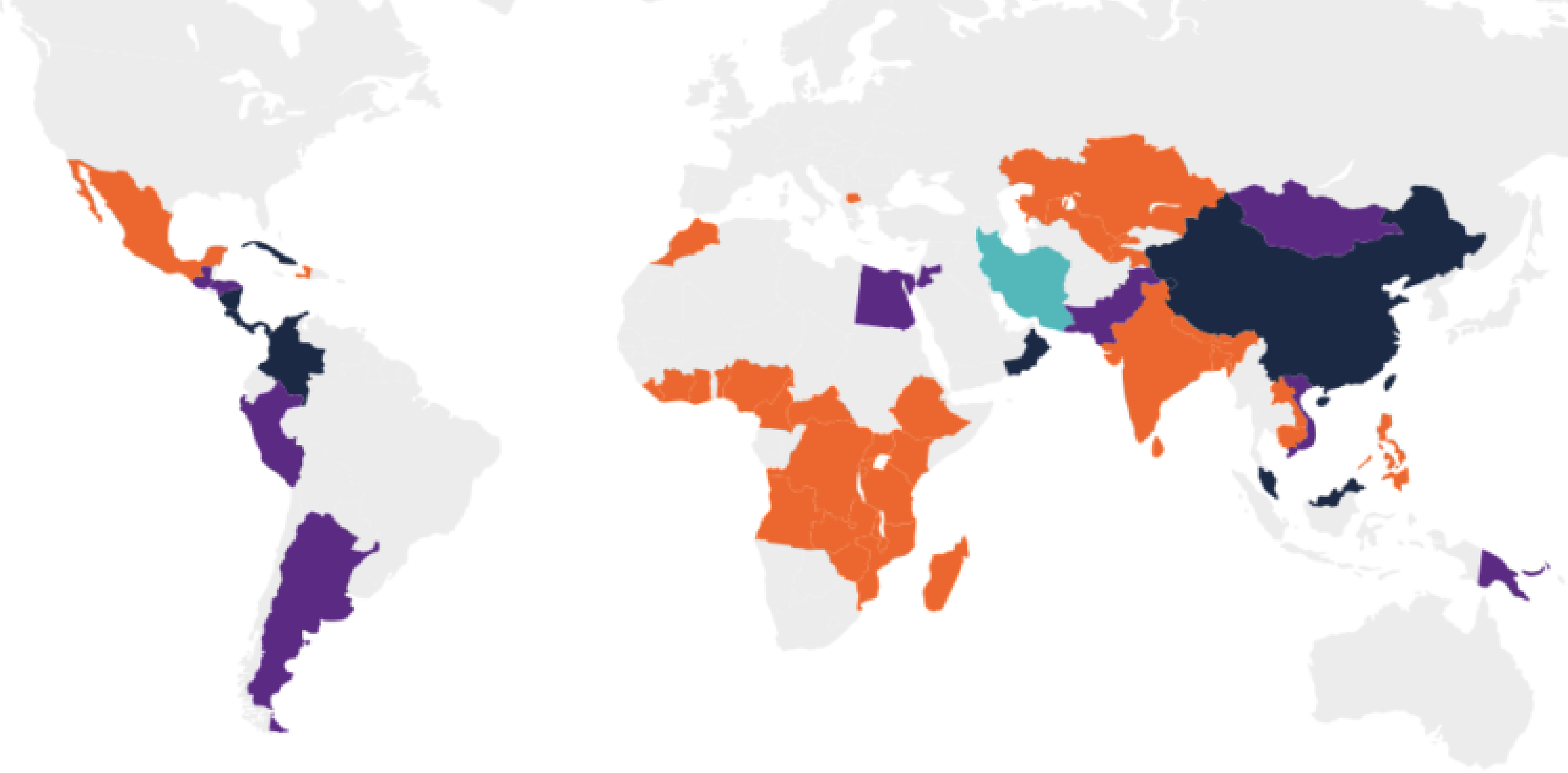
- Odroda ryže geneticky upravená tak, aby produkovala veľké množstvá β-karoténu (provitamín A)
- Bola vytvorená s humanitárnym zámerom:
  - Celosvetovo trpí ročne nedostatkom vitamínu A (VAD) 125 miliónov detí pod 5 rokov, pričom 250 – 500 tisíc detí ročne v jej následku oslepne. Viac ako polovica detí, ktoré oslepnú, do roka zomrie.
  - VAD tiež spôsobuje zhoršenú funkciu imunitného systému, anémiu a spomalený rast.
  - Zlatá ryža by dokázala tento problém vyriešiť, keďže už 60 g zlatej ryže denne (polka hrnčeka) obsahuje 60 % doporučenej dennej dávky (čínskej) pre deti vo veku 6-8 rokov. Čo je dostatočné množstvo na to, aby sa zabránilo VAD.

Figure 1. Worldwide prevalence of vitamin A deficiency.

Map showing the prevalence of biochemical vitamin A deficiency in children under five, as indicated by a serum retinol concentration <0.70 μmol/l. Based on data collected by WHO between 1995 and 2005 in populations at risk of vitamin A deficiency.

Level of vitamin A deficiency

- *Severe (≥20%)*
- *Moderate (≥10% - <20%)*
- *Mild (≥2% - <10%)*
- *None (<2%)*
- *No data*

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www.time.com AOL Keyword: TIME
TIME
THIS RICE COULD SAVE A MILLION KIDS A YEAR
...but protesters believe such genetically modified foods are bad for us and our planet. Here's why.
Swiss Professor Ingo Potrykus with his beta-carotene-enriched rice

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The Guardian

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GM

Nobel winners slam Greenpeace for anti GM campaign

About a third of living Nobel laureates sign an open letter saying Greenpeace has misrepresented the risks and benefits of genetically modified crops

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Stop Bashing G.M.O. Foods, More Than 100 Nobel Laureates Say

The Washington Post
Democracy Dies in Darkness

Speaking of Science

107 Nobel laureates sign letter blasting Greenpeace over GMOs

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JUN 29, 2016 @ 03:41 PM 17,555

More Than 100 Nobel Laureates Call Out Greenpeace For Anti-GMO Obstruction In Developing World

159 Laureates Supporting Precision Agriculture (GMOs)

Peter Agre	2003	Chemistry
Zhores I. Alferov *	2000	Physics
Sidney Altman	1989	Chemistry
Hiroshi Amano	2014	Physics
Werner Arber	1978	Medicine
Frances H. Arnold	2018	Chemistry
Richard Axel	2004	Medicine
David Baltimore	1975	Medicine
Barry Clark Barish	2017	Physics
J. Georg Bednorz	1987	Physics
Paul Berg	1980	Chemistry
Bruce A. Beutler	2011	Medicine
Gerd Binnig	1986	Physics

Volume 19, Issue 6 December 2014 , pp. 724-742

The economic power of the Golden Rice opposition

Justus Wesseler [a1] and David Zilberman [a2]

https://doi.org/10.1017/S1355770X1300065X Published online: 22 January 2014

Abstract

Vitamin A enriched rice (Golden Rice) is a cost-efficient solution that can substantially reduce health costs. Despite Golden Rice being available since early 2000, this rice has not been introduced in any country. Governments must perceive additional costs that overcompensate the benefits of the technology to explain the delay in approval. We develop a real option model including irreversibility and uncertainty about perceived costs and arrival of new information to explain a delay in approval. The model has been applied to the case of India. Results show the annual perceived costs have to be at least US$199 million per year approximately for the last decade to explain the delay in approval of the technology. This is an indicator of the economic power of the opposition towards Golden Rice resulting in about 1.4 million life years lost over the past decade in India.

The model has been applied to the case of India. Results show the annual perceived costs have to be at least US$199 million per year approximately for the last decade to explain the delay in approval of the technology. This is an indicator of the economic power of the opposition towards Golden Rice resulting in about 1.4 million life years lost over the past decade in India.

AquAdvantage® salmon

- Vyvinutý v roku 1989 vložením jednej kópe *opAFP-GHc2* konštruktu, ktorý obsahuje promotor zo Slimule americké (*Zoarces americanus*), za ktorým je umiestnený rastový hormón z Lososa čavyča (*Oncorhynchus tshawytscha)*
- Narastie do požadovanej velkosti na predaj za 16-18 mesiacov v porovnaní s 3 rokmi, ktoré to trvá nemodifikovaným lososom
- Na chov sa používaj triploidné sterilné samičky, ktoré majú navyše kvalitnejšie mäso, pretože nemusie investovať' energiu na reprodukciu.
- Fertilný samčekovia a samičky sú skladované v nádržiach, ktoré niesu v žiadnom kontakte s oceánom

nature

MEDICAL & BIOTECH

First Genetically Engineered Salmon Sold in Canada

US firm AquaBounty Technologies says that its transgenic fish has hit the market after a 25-year wait

By Emily Waltz, Nature on August 7, 2017

Zhrnutie GMO

pozitíva

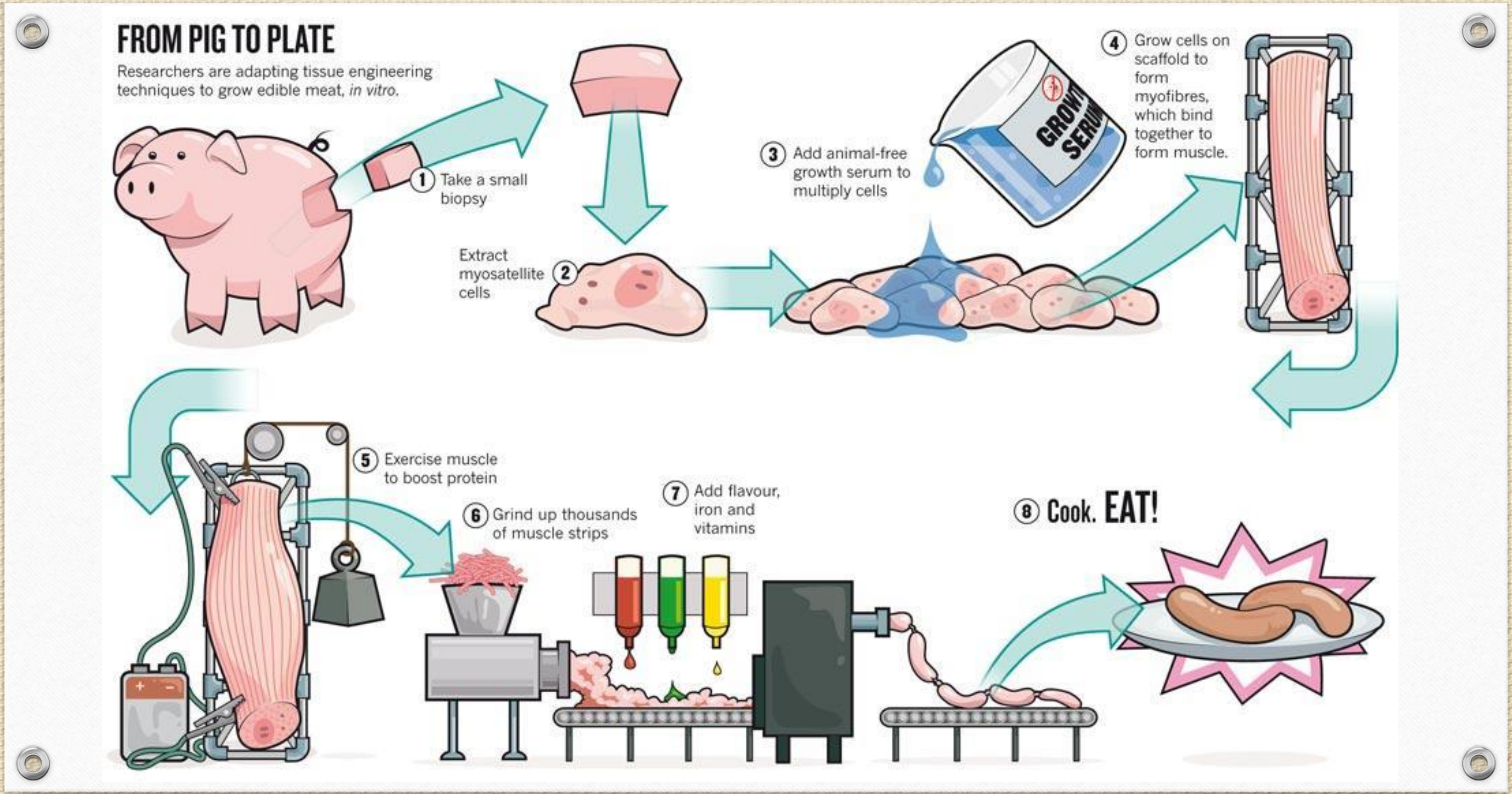
- Principiálne rýchlejšie ako klasické metódy šľachtenia
- Vieme presne, aké genetické zmeny nastali v modifikovanom organizme
- Majú veľký potenciál byť ekonomickejšie, ekologickejšie a zdravšie ako alternatívy
- Je nimi možné dosiahnuť aj zmeny, ktoré nie je možné vyšľachtiť „klasickými“ metódami

negatíva

- Často negatívny postoj verejnosti
- Vyžadujú dobrú znalosť genetiky daného znaku
- Pre neistotu úspešného zavedenia na trh sa často jedná o rizikovú investíciu

In vitro mäso

(nie je GMO)


FROM PIG TO PLATE
Researchers are adapting tissue engineering techniques to grow edible meat, *in vitro*.
1 Take a small biopsy
Extract myosatellite cells 2
3 Add animal-free growth serum to multiply cells
GROWTH SERUM
4 Grow cells on scaffold to form myofibres, which bind together to form muscle.
5 Exercise muscle to boost protein
6 Grind up thousands of muscle strips
7 Add flavour, iron and vitamins
8 Cook. EAT!

Cena?

- Prvé pokusy s tvorbou *in vitro* mäsa začali približne v roku 2000
- Prvý v laboratóriu vypestovaný hamburger bol verejne zjedený (počas nahrávania televíziou) v roku 2013 a jeho vypestovanie stálo 250 000 dolárov
- Ceny výroby *in vitro* mäsa však prudko klesajú a je možné, že prvé komerčne predávané *in vitro* mäso sa na trhu v USA objaví už v blízkej dobe

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News › Science

Lab-grown 'clean' meat could be on sale by end of 2018, says producer

Cultured tissue, harvested without killing any animals, could allow scientists to grow meals' worth of products with just a handful of starter cells

CNN Health » Food | Fitness | Wellness | Parenting | Vital Signs International Edition +

How close are we to a hamburger grown in a lab?

By Charlotte Hawks, CNN

Updated 1923 GMT (0323 HKT) March 8, 2018

Meat industry

This article is more than **4 months old**

No-kill, lab-grown meat to go on sale for first time

Singapore's approval of chicken cells grown in bioreactors is seen as landmark moment across industry

Damian Carrington
Environment editor
@dpcarrington
Wed 2 Dec 2020 00.01 GMT

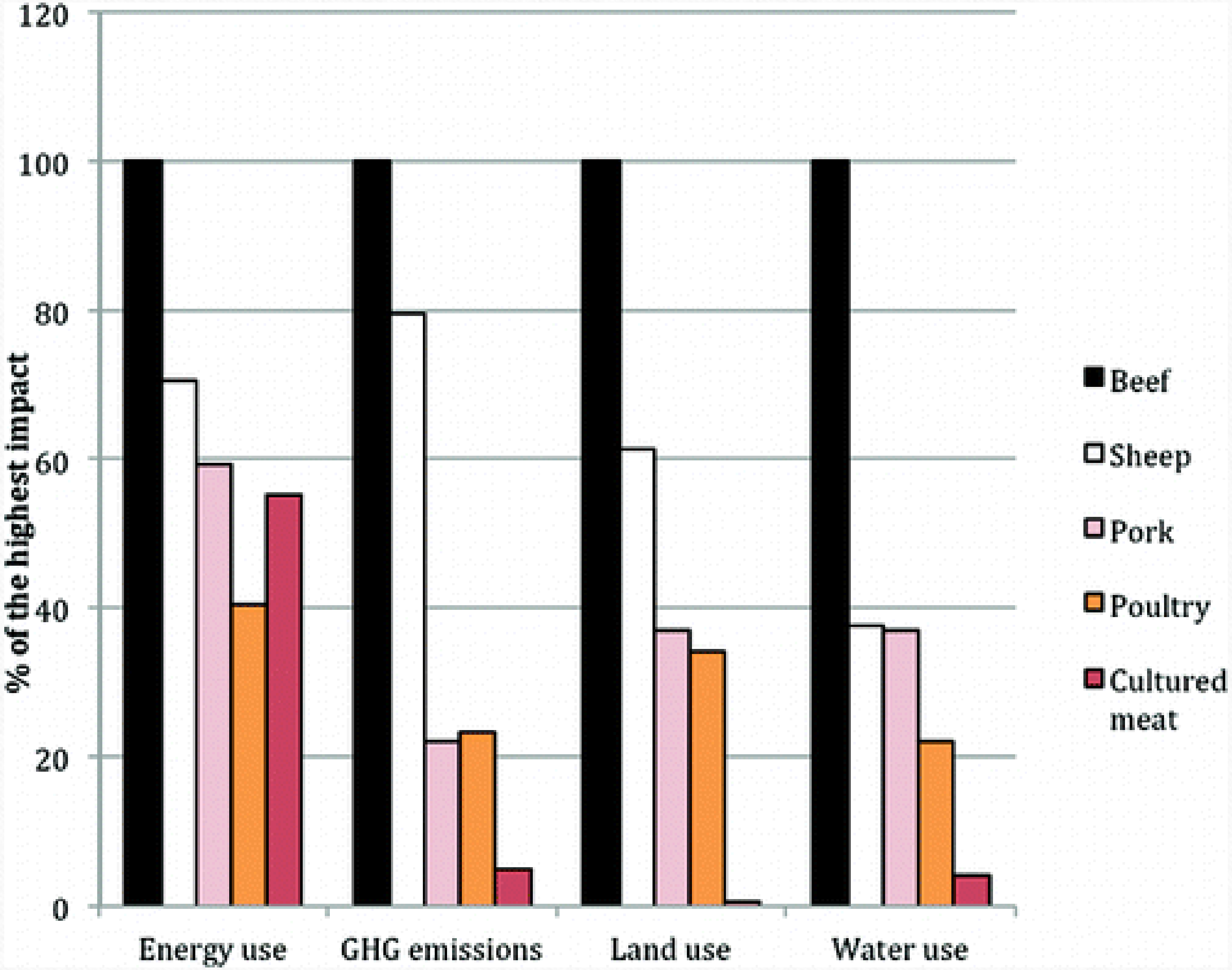
Lab-grown fish makes a debut in Hong Kong

Hong Kong food tech startup Avant Meats has developed lab-grown fish fillets, capitalising on the growing demand for seafood that doesn't jeopardise ocean biodiversity.

STARTUPS · ALTERNATIVE PROTEINS · SUSTAINABILITY · ENVIRONMENT

F

by The Fish Site
29 January 2021, at 8:00am



(Tuomisto and Mattos, 2011)

DODO NUGGETS

★ ★ ★ ★

ADD TO MENU

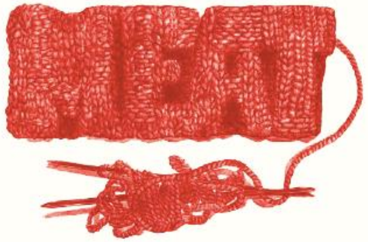
CHOOSE ANOTHER STARTER

The dodo is back on the menu. Thanks to a dried specimen of a dodo in the Oxford University Natural History Museum it is possible to taste what the first sailors ate when they visited Mauritius in 1598. Tissue engineering and advanced genetic sequencing have allowed food scientists to reanimate this long-extinct species. Children love the taste of cutting-edge science, especially served with our sweet honey and mustard dipping sauce.

BISTRO IN VITRO MENU CHEFS REVIEWS RESERVATION

WELCOME TO BISTRO IN VITRO

Hello meat eaters, hello vegetarians. Welcome to Bistro In Vitro, the restaurant for trailblazers, world changers and nature lovers. We cook to a high standard using the latest culinary techniques and a revolutionary new ingredient: in vitro meat. Welcome to the restaurant of the future!



WHY IN VITRO MEAT?

Now that the world population is heading for 9 billion in 2050, our current way of producing and consuming meat is fast becoming unsustainable. Global warming, energy consumption, animal diseases and the anticipated worldwide food shortage are just some of the pressing food related issues we will need to address, and that is before we have even considered the much debated issue of animal cruelty and factory farming.

PIG IN THE GARDEN

★ ★ ★

ADD TO MENU

CHOOSE ANOTHER MAIN COURSE

Meat comes from living animals, and that goes for the stem cells needed for in vitro meat as well. The pig in the restaurant's garden is a living repository of stem cells for the pork shoulder on our menu. Interested in meeting the pig with your dinner companions? Ask your waitress, and she will happily escort you.

A FICTITIOUS RESTAURANT

Bistro In Vitro is a fictitious restaurant with a menu of in vitro dishes that may one day end up on your plate. We prepare exclusive cuts of meat, cultured and prepared with surprising flavours and textures that you would never encounter in the wild. By exploring and pushing the boundaries of our food culture we want to do away with the idea that cultured meat is an inferior meat substitute. That is why we serve you a digital selection of sustainable, animal friendly, exciting and delicious dishes that will prompt thought and discussion on in vitro meat.

www.supermeat.com
www.thechicken.kitchen

Press Release

Tel Aviv, Israel, 30 October 2020

World's first cultured chicken restaurant experience launch

From today, anyone who's excited about cultured meat can apply for a table at SuperMeat's test kitchen to enjoy meat grown from chicken cells at SuperMeat's factory-side restaurant experience, The Chicken.

The mission to bring cultured meat to the dinner table moves a tangible step closer this week with the launch of The Chicken – the world's first restaurant experience that provides interested individuals the opportunity to eat meat grown directly from chicken cells.

Opened by food tech company SuperMeat, this development is a significant milestone for the cultured meat industry, addressing the three key challenges for commercialization: a scalable manufacturing process; a clear path to cost parity with conventional meat, and the production of high-quality and nutritious chicken products that taste incredible.

OUR MISSION | OUR MEAT | MANUFACTURING | PRESS KIT | CAREERS | CONTACT US | APPLY FOR A TABLE

NUTRITIOUS

Our meat is produced from high-quality, healthy chicken cells, with no genetic engineering involved. It is grown in a nutritious feed, with no antibiotics and in a completely contaminant-free environment.

Menu
Apply for a Table
Contact Us
THE Chicken