UNI FREIBURG

Synthetischer Biodiversitätsschutz

Prof. Dr. Gernot Segelbacher

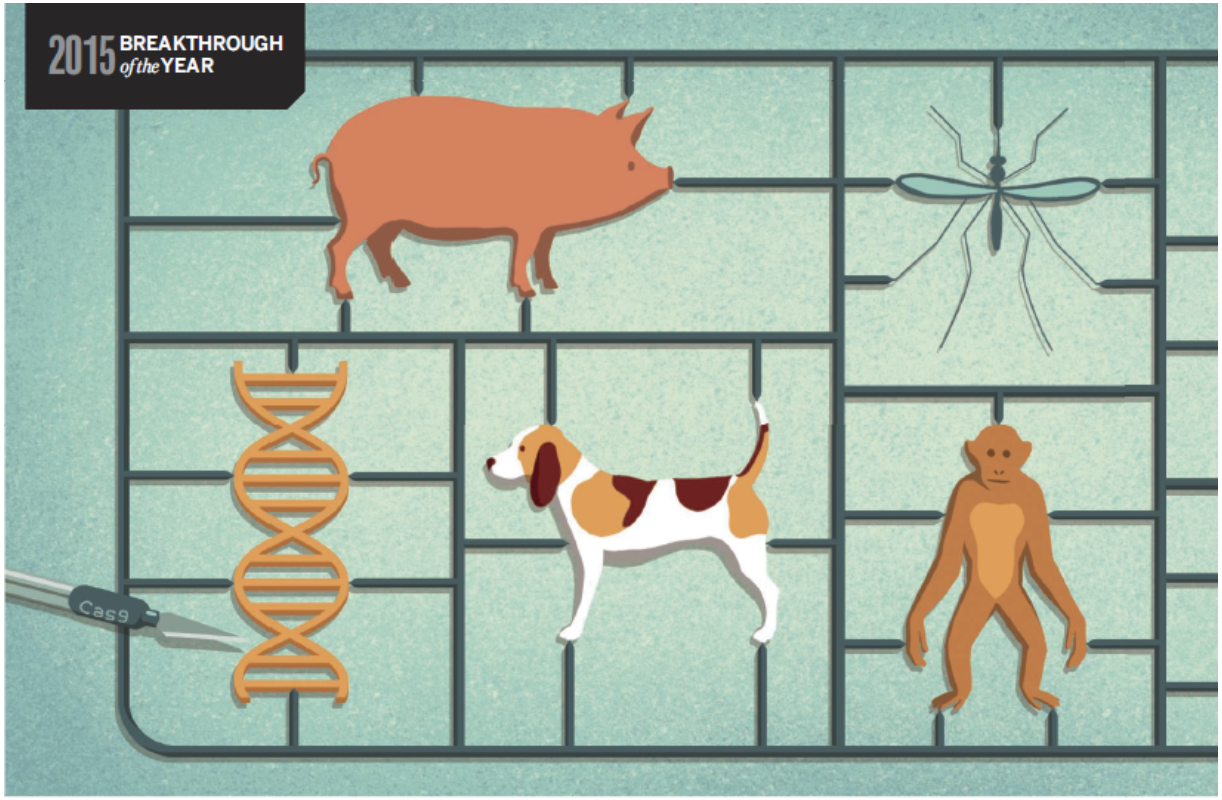
CONSERVATION GENETICS
SPECIALIST GROUP

Was ist synthetische Biologie?

Was ist die wichtigste technische Errungenschaft der letzten Jahrzehnte?

Veränderung des Erbguts

Veränderung des Erbguts



Making the cut

CRISPR genome-editing technology shows its power

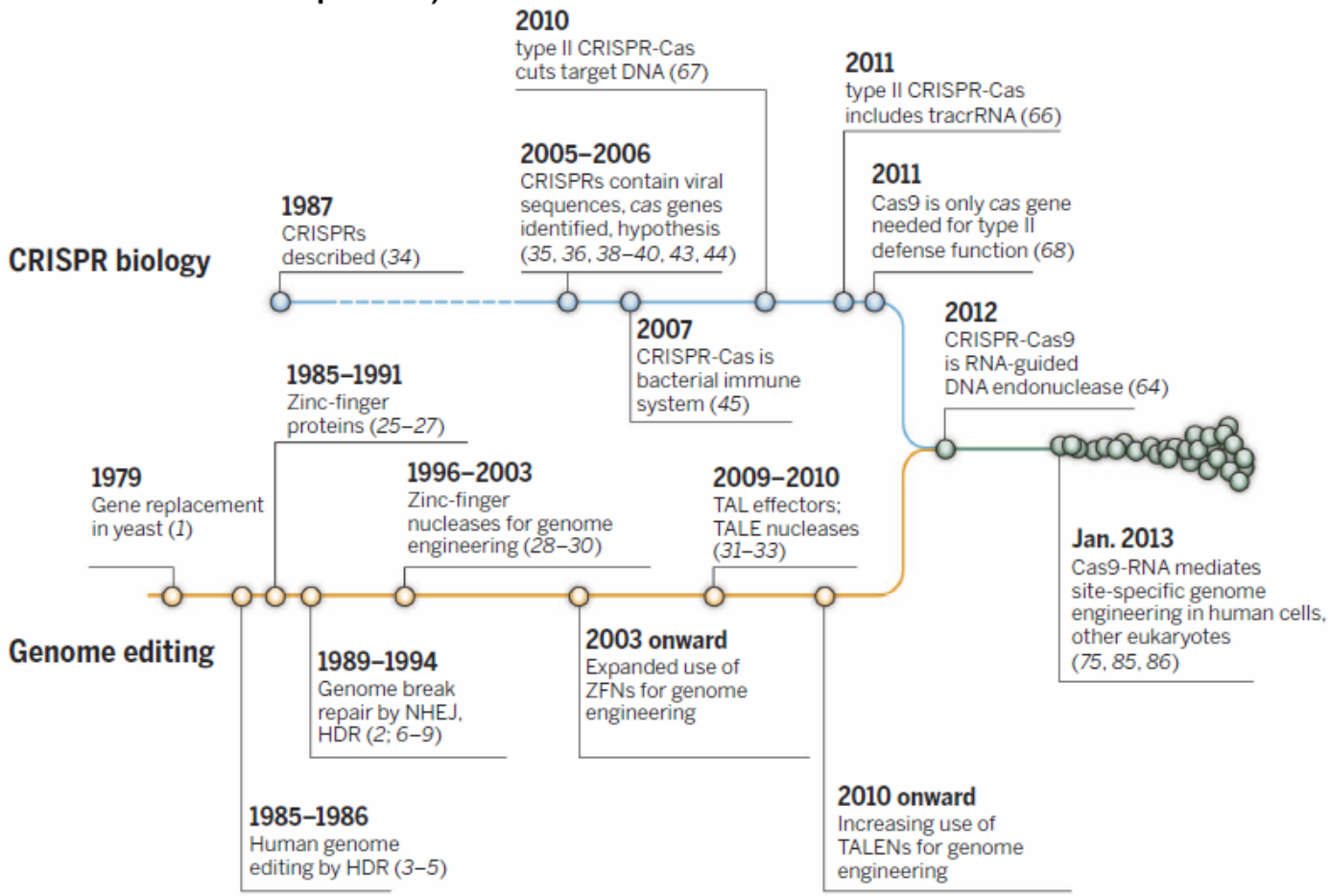
By **John Travis**

ILLUSTRATION: DAVIDE BONAZZI/@SALZMANART

Travis Science 2015

CRISPR

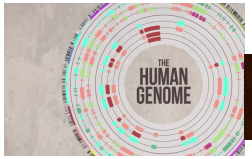
Clustered **R**egularly **I**nterspaced **S**hort **P**alindromic **R**epeats)



Doudna & Charpentier Science 2014

Geschichte der GMOs

1973	recombinante DNA
1977	Transgenes Tier
1982	schnelle DNA sequenzierung
1983	Künstlich erzeugtes Insulin
	PCR
	genetisch veränderte Pflanze
1997	Somatischer Zell Transfer
2000	human genome
2009	veränderte moskitos
2010	Synthetisches Bakteriengenom
2014	CRISPR Cas9
2015	GM Tier als Nahrung



Warum ist CRISPR so wichtig?

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Genom veränderung durch CRISPR-CAS9

präzise, effizient, billig, einfach durchführbar

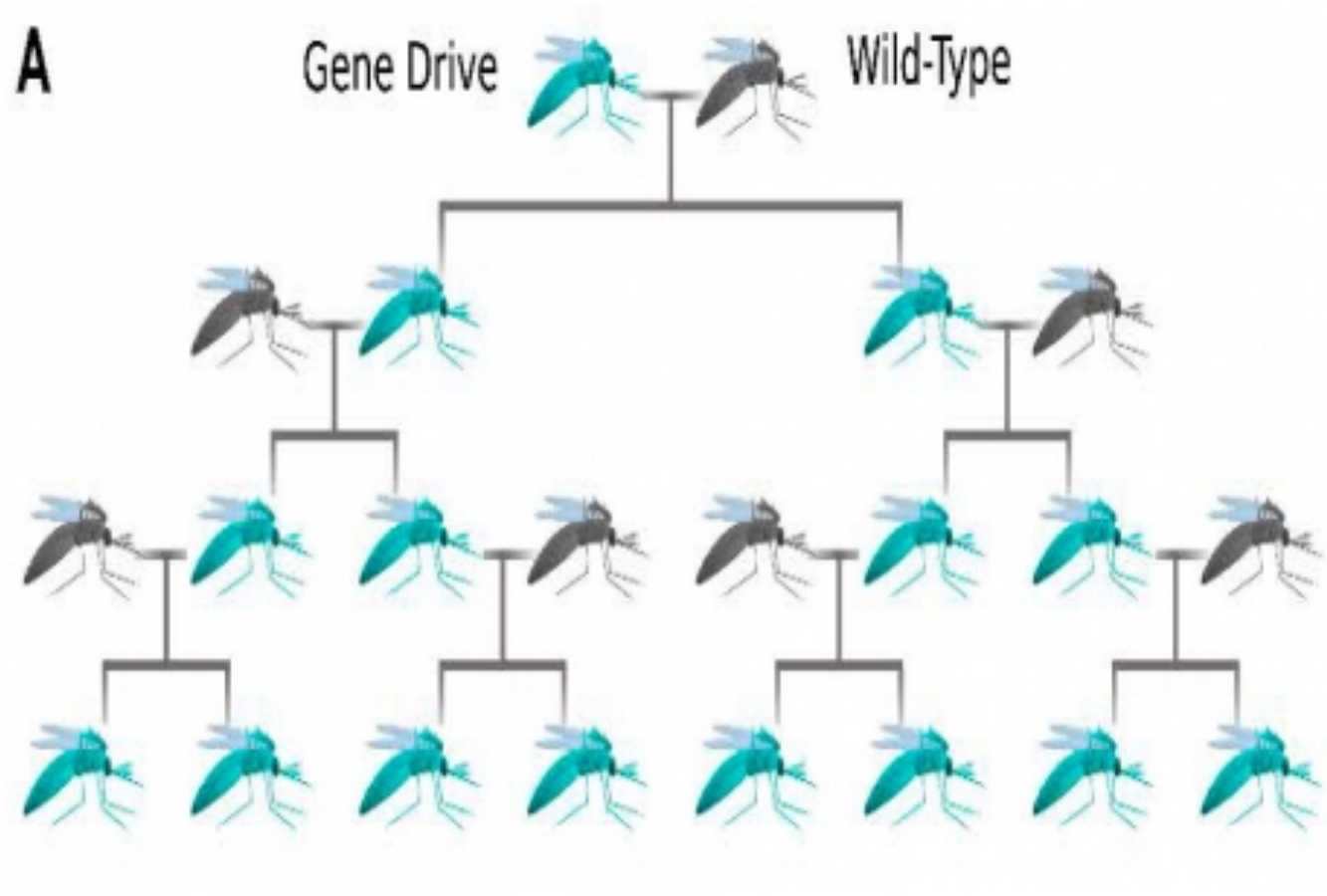
gene drive

eine genetische Veränderung, die sich in einer Population von einer Generation zur nächsten durchsetzt

(synthetische Elemente werden dazu gemacht ihre Frequenz von einer Generation zur nächsten zu erhöhen)

-> künstliche Gene können sich damit schneller als durch klassische genetische Vererbung verbreiten

gene drive

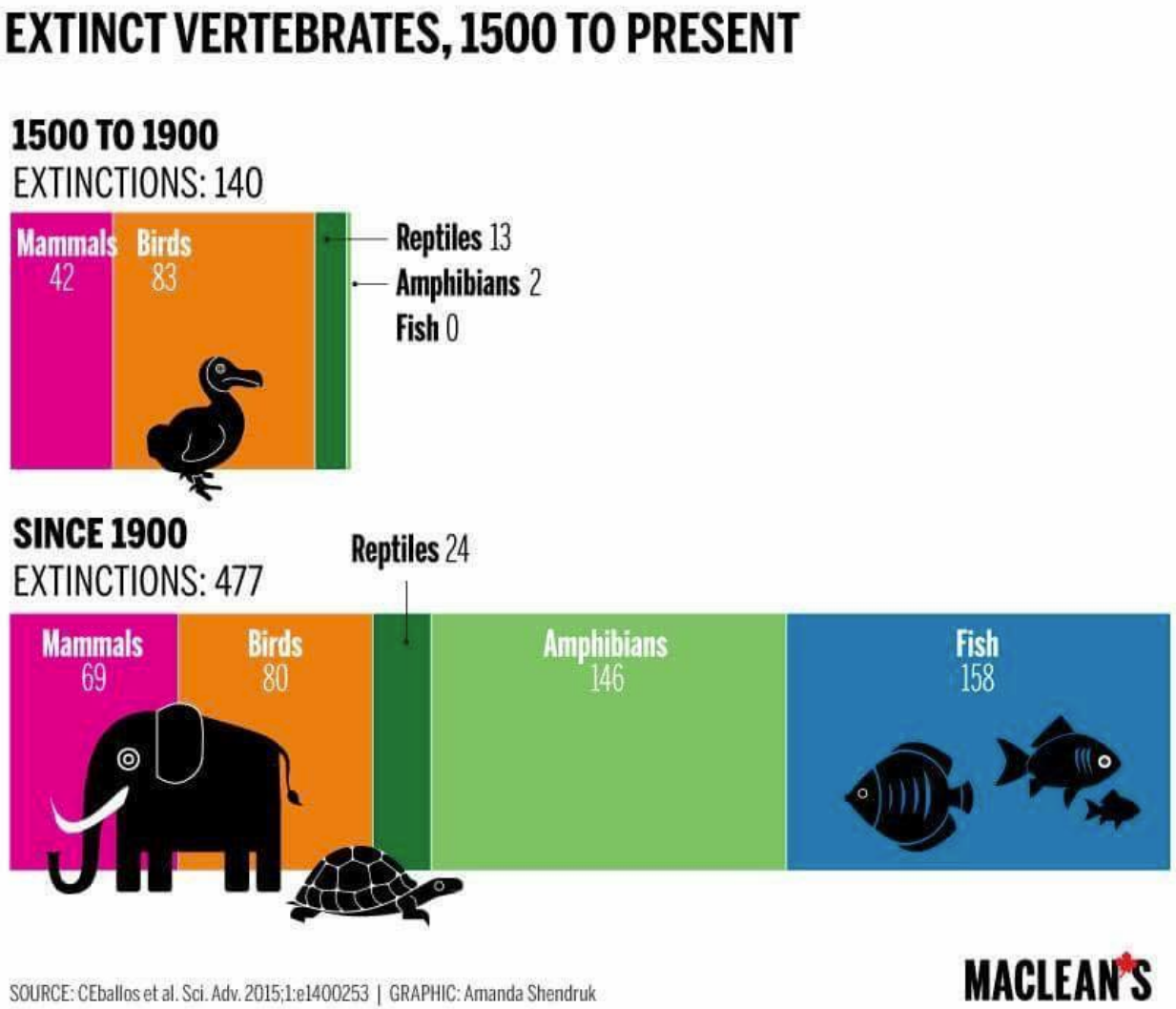


http://news.cornell.edu/stories/2015/10/new-gene-drive-technology-evokes-hopes-and-fears

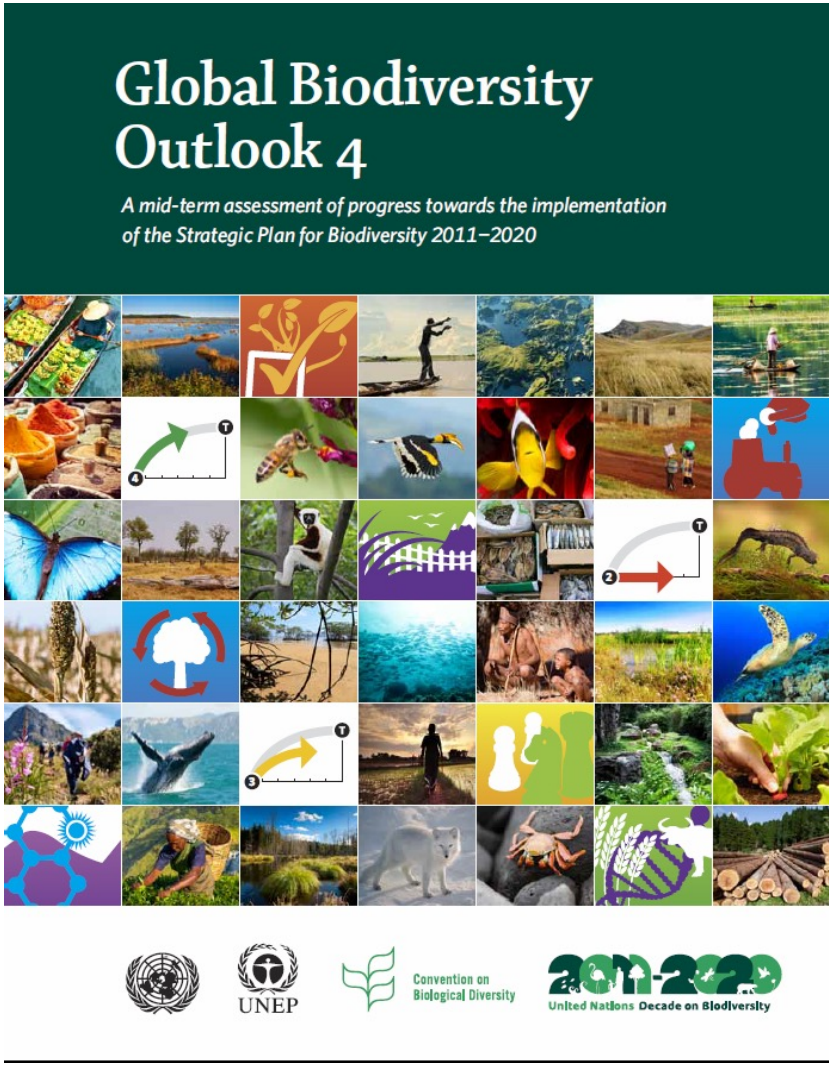
haben Menschen im Laufe der Geschichte nicht schon immer Genome verändert?

Verlust der Biodiversität

Verlust der Biodiversität



Verlust der Biodiversität



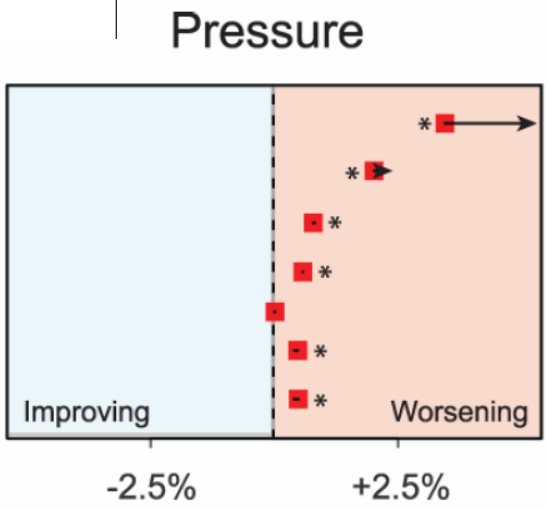
Verlust der Biodiversität

Sciencexpress Reports

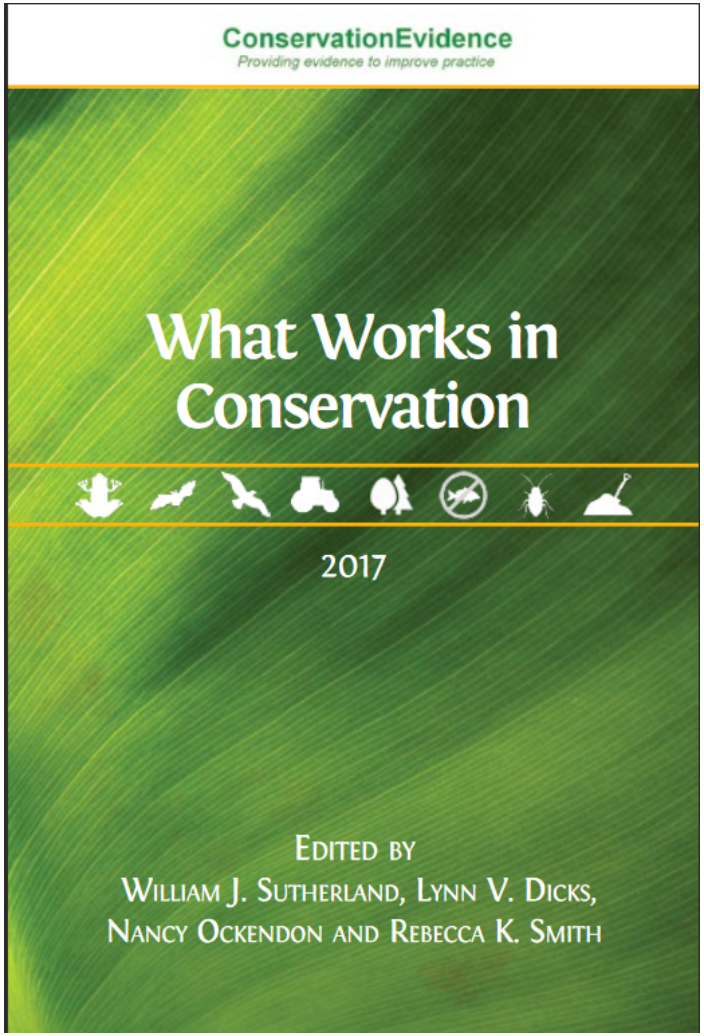
CONSERVATION TARGETS

A mid-term analysis of progress toward international biodiversity targets

Derek P. Tittensor,[1,2*] Matt Walpole,[1] Samantha L. L. Hill,[1] Daniel G. Boyce,[3,4] Gregory L. Britten,[2] Neil D. Burgess,[1,5] Stuart H. M. Butchart,[6] Paul W. Leadley,[7] Eugenie C. Regan,[1] Rob Alkemade,[8] Roswitha Baumung,[9] Céline Bellard,[7] Lex Bouwman,[8,10] Nadine J. Bowles-Newark,[1] Anna M. Chenery,[1] William W. L. Cheung,[11] Villy Christensen,[11] H. David Cooper,[12] Annabel R. Crowther,[1] Matthew J. R. Dixon,[1] Alessandro Galli,[13] Valérie Gaveau,[14] Richard D. Gregory,[15] Nicolas L. Gutierrez,[16] Tim L. Hirsch,[17] Robert Höft,[12] Stephanie R. Januchowski-Hartley,[18] Marion Karmann,[19] Cornelia B. Krug,[7,20] Fiona J. Leverington,[21] Jonathan Loh,[22] Rik Kutsch Lojenga,[23] Kelly Malsch,[1] Alexandra Marques,[24,25] David H. W. Morgan,[26] Peter J. Mumby,[27] Tim Newbold,[1] Kieran Noonan-Mooney,[12] Shyama N. Pagad,[28] Bradley C. Parks,[29] Henrique M. Pereira,[24,25] Tim Robertson,[17] Carlo Rondinini,[30] Luca Santini,[30] Jörn P. W. Scharlemann,[1,31] Stefan Schindler,[32,33] U. Rashid Sumaila,[11] Louise S.L. Teh,[11] Jennifer van Kolck,[8] Piero Visconti,[34] Yimin Ye[9]



http://science.sciencemag.org/content/346/6206/241



http://www.conservationevidence.com/

Hauptursachen

Habitatverlust

Krankheiten

Invasive Arten

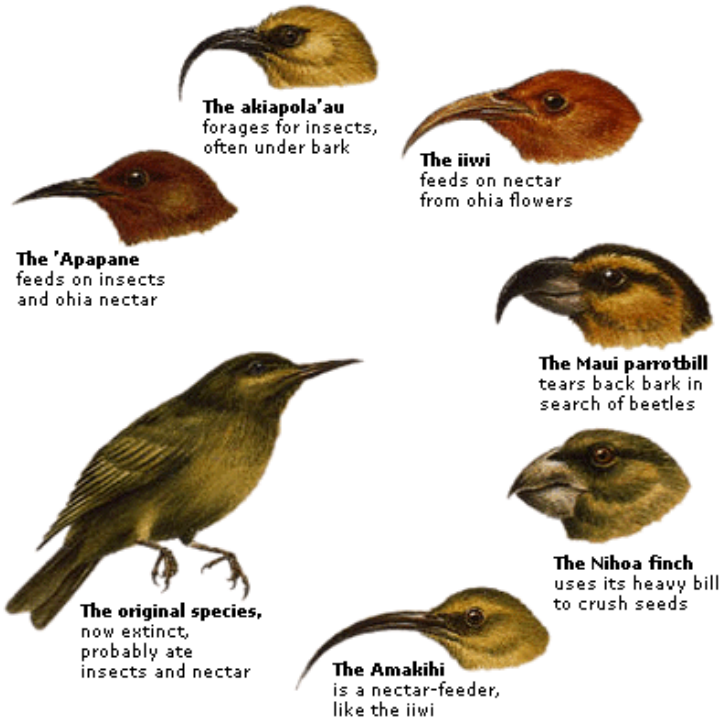
Hauptursachen

Habitatverlust

Krankheiten

Invasive Arten

Vögel Hawai



33 out of 42 extinct

http://biologyreasoning.wikispaces.com/Darwins+Theroy+of+evolution

Vogelmalaria als Bedrohung

Culex quiquefasciatus (1826 introduced)

https://en.wikipedia.org/wiki/Scarlet_Hawaiian_Honeycreeper
http://www.uniprot.org/taxonomy/7176

“We have five, 10, maybe 15 years before we start seeing more declines…but some of these species don’t have that much time and I don’t want to see another species become extinct in my lifetime.”

Pete Marra, director of the Smithsonian Institution’s Migratory Bird Center.

Was wäre wenn….

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Was wäre wenn….

wir Malaria eindämmen könnten?

Moskitos

LETTERS

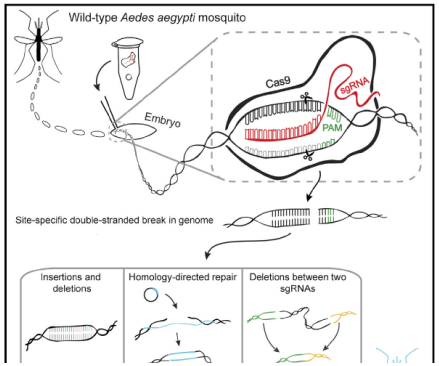
nature biotechnology

A CRISPR-Cas9 gene drive system targeting female reproduction in the malaria mosquito vector *Anopheles gambiae*

Andrew Hammond[1], Roberto Galizi[1], Kyros Kyrou[1], Alekos Simoni[1], Carla Siniscalchi[2], Dimitris Katsanos[1], Matthew Gribble[1], Dean Baker[3], Eric Marois[4], Steven Russell[3], Austin Burt[1], Nikolai Windbichler[1], Andrea Crisanti[1] & Tony Nolan[1]

Genome Engineering with CRISPR-Cas9 in the Mosquito *Aedes aegypti*

Graphical Abstract



Authors
Kathryn E. Kistler, Leslie B. Vosshall, Benjamin J. Matthews

Correspondence
ben.matthews@rockefeller.edu

In Brief
The mosquito *Aedes aegypti* is responsible for infecting hundreds of millions of humans with life-threatening diseases each year. Kistler et al. show that CRISPR-Cas9 can be used to engineer precise loss-of-function mutations and targeted integration of exogenous sequences, enabling detailed genetic study of this deadly disease vector.

CrossMark
click for updates

PNAS

Highly efficient Cas9-mediated gene drive for population modification of the malaria vector mosquito *Anopheles stephensi*

Valentino M. Gantz[a,1], Nijole Jasinskiene[b,1], Olga Tatarenkova[b], Aniko Fazekas[b], Vanessa M. Macias[b], Ethan Bier[a,2], and Anthony A. James[b,c,2]

[a]Section of Cell and Developmental Biology, University of California, San Diego, La Jolla, CA 92093-0349; [b]Department of Molecular Biology and Biochemistry, University of California, Irvine, CA 92697-3900; and [c]Department of Microbiology and Molecular Genetics, School of Medicine, University of California, Irvine, CA 92697-4500

A practical guide to genome-engineering with CRISPR-Cas9 in the mosquito *Aedes aegypti*

Kathryn E Kistler, Leslie B Vosshall, and Benjamin J Matthews *

February 4, 2015

Abstract

The following protocol is designed to help researchers generate precise genomic alterations in the mosquito *Aedes aegypti* using the CRISPR-Cas9 system of RNA-guided nucleases. A companion pre-print can be found at `http://biorxiv.org/content/early/2014/12/30/013276`.

Vögel auf Inseln

IBIS The International Journal of Avian Science
Ibis (2010), **152**, 443–458

Review article

The catastrophic impact of invasive mammalian predators on birds of the UK Overseas Territories: a review and synthesis

GEOFF M. HILTON[1]* & RICHARD J. CUTHBERT[2]
[1]*Wildfowl and Wetlands Trust, Slimbridge, Gloucestershire GL2 7BT, UK*
[2]*Royal Society for the Protection of Birds, The Lodge, Sandy, Bedfordshire SG19 2DL, UK*

PNAS

Invasive mammal eradication on islands results in substantial conservation gains

Holly P. Jones[a,b,1], Nick D. Holmes[c], Stuart H. M. Butchart[d], Bernie R. Tershy[e], Peter J. Kappes[f], Ilse Corkery[g], Alfonso Aguirre-Muñoz[h], Doug P. Armstrong[i], Elsa Bonnaud[j], Andrew A. Burbidge[k], Karl Campbell[c,l], Franck Courchamp[j], Philip E. Cowan[m], Richard J. Cuthbert[n,o], Steve Ebbert[p], Piero Genovesi[q,r], Gregg R. Howald[c], Bradford S. Keitt[c], Stephen W. Kress[s], Colin M. Miskelly[t], Steffen Oppel[n], Sally Poncet[u], Mark J. Rauzon[v], Gérard Rocamora[w,x], James C. Russell[y,z], Araceli Samaniego-Herrera[h], Philip J. Seddon[aa], Dena R. Spatz[c,e], David R. Towns[bb,cc], and Donald A. Croll[e]

https://de.wiktionary.org/wiki/Wanderratte

Ausrottung von Ratten

http://www.antarcticabound.com/blog/wp-content/uploads/helicopter_resupply.jpg.size_.xxlarge.letterbox.jpg
http://www.galapagos.org/wp-content/uploads/2012/01/rat-eradication-on-rabida.jpg

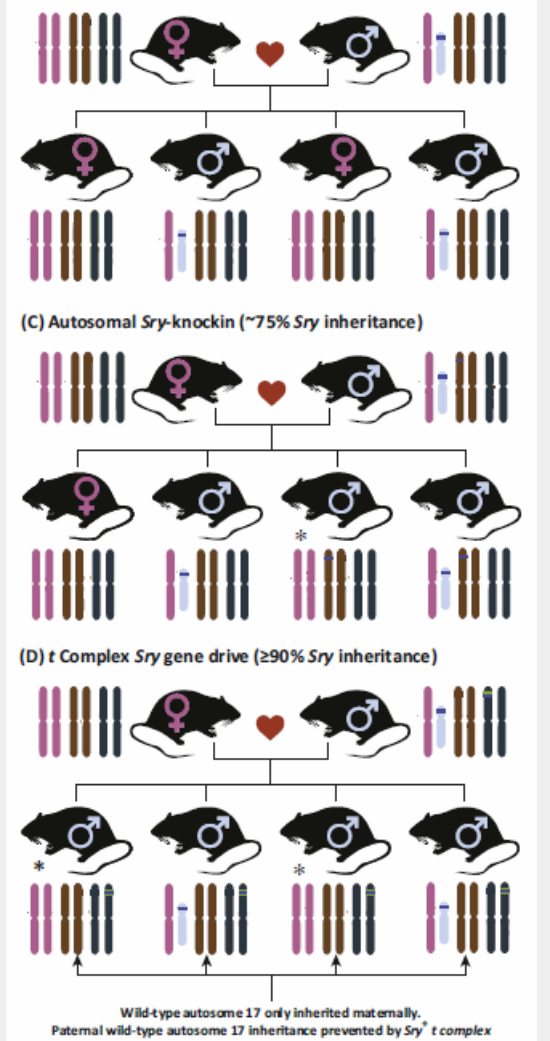
Vergiftungen

https://ajh57.files.wordpress.com/2013/01/striated-caracara3.jpg

Was wäre wenn….

Was wäre wenn….

wir invasive Arten eindämmen könnten?


(C) Autosomal *Sry*-knockin (~75% *Sry* inheritance)
(D) *t* Complex *Sry* gene drive (≥90% *Sry* inheritance)
Wild-type autosome 17 only inherited maternally.
Paternal wild-type autosome 17 inheritance prevented by *Sry*$^{+}$ *t complex*

Risikoabschätzung

Nutzen

++

(Aussterben verhindert,
natürlicher Lebensraum wieder hergestellt)

Risikoabschätzung

Nutzen

++

(Aussterben verhindert,
natürlicher Lebensraum wieder hergestellt)

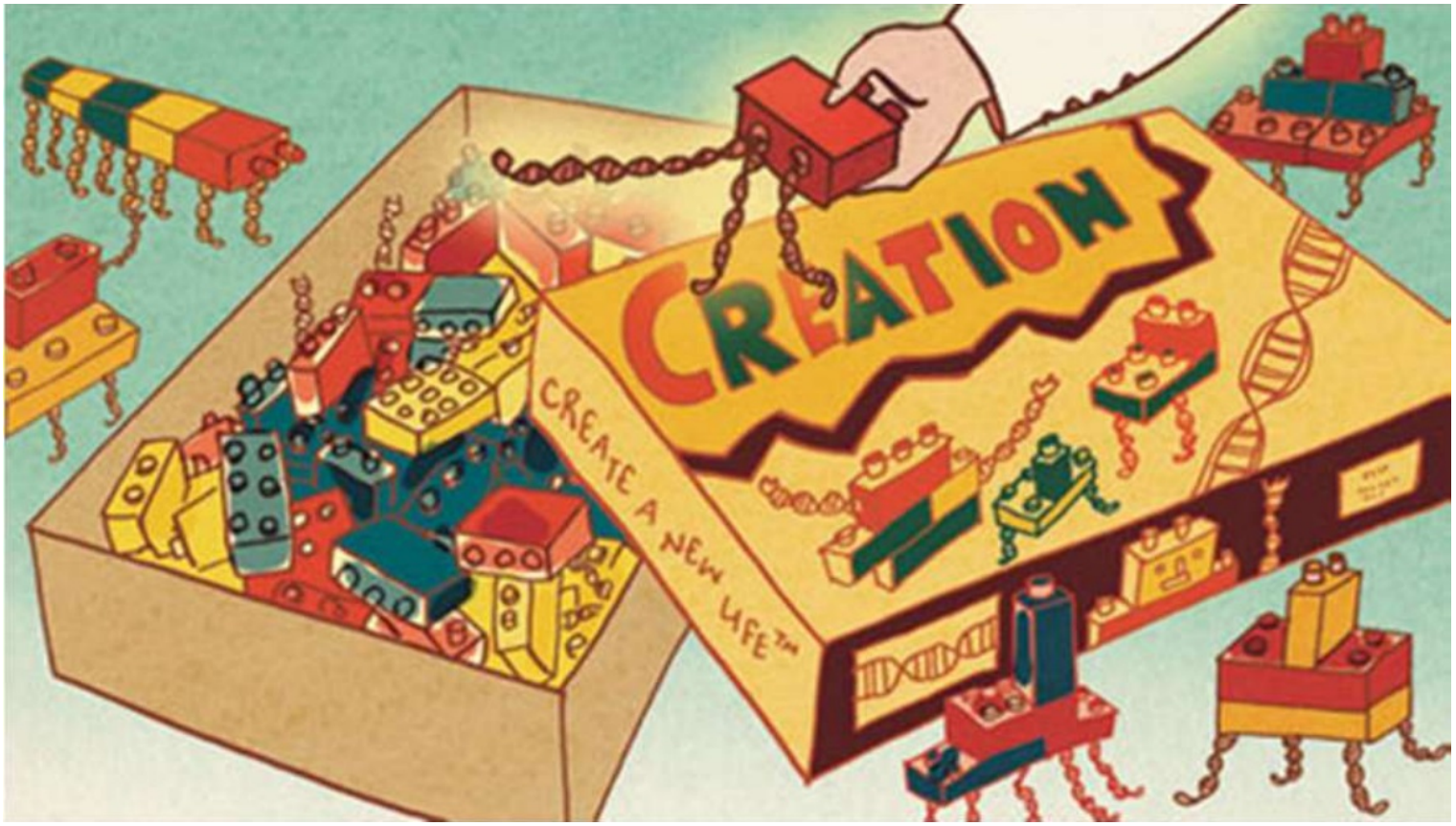
Risiko der Nichtnutzung

Verlust der Arten (keine Zeit mehr)

Risiko

-

Ausbreitung ans Festland
Hybridisierung mit anderen Arten



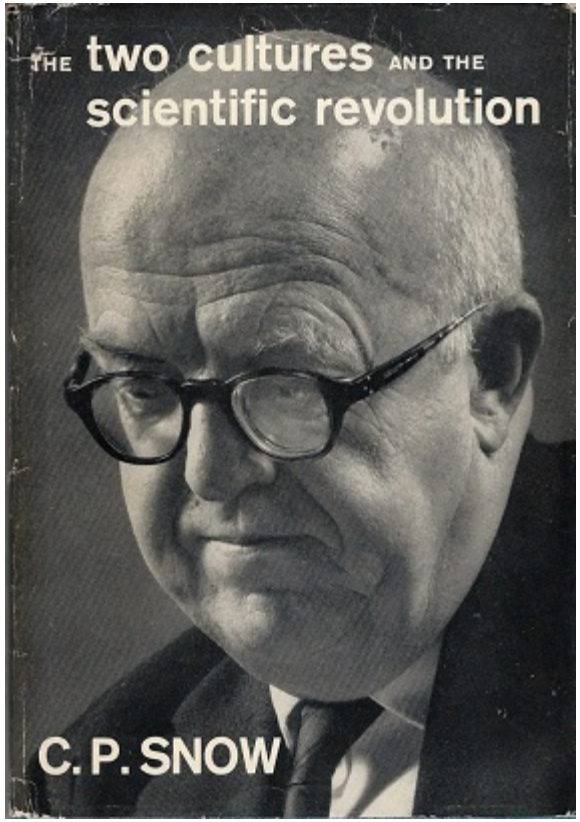
https://loonylabs.org/2015/06/25/synthetic-biology-biochemicals/

http://4.bp.blogspot.com/_uSsaLT9Bsxc/TTy9_X0Y8HI/AAAAAAAAAMA/lqywcbFXPU4/s400/wirhabenessatt%2B046.jpg

Zwei Kulturen

"… *identified two cultures: those of the literary intellectuals and of the natural scientists, between who he claimed to find a profound mutual suspicion and incomprehension, which in turn has damaging consequences for the prospects of applying technology to the alleviation of the world's problems"*

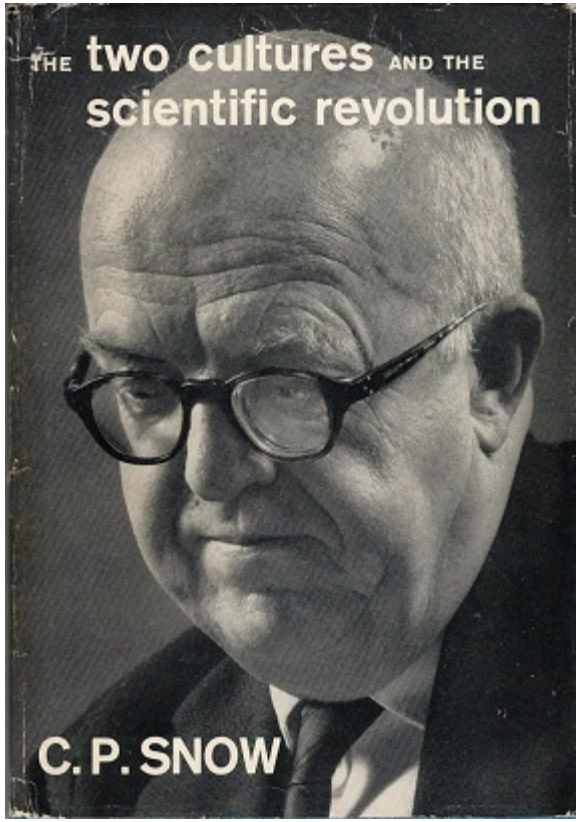
1959



(Extract from Collin Introduction of (Snow 1998).

http://blogs.britannica.com/wp-content/uploads/2009/07/snow-book.jpg

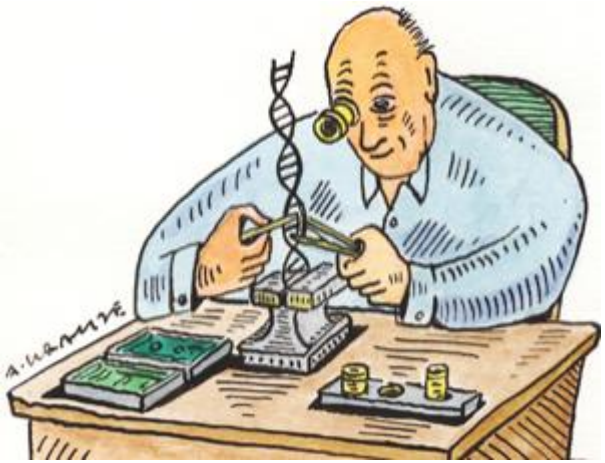
Bewahren – Gestalten ?



Was ist synthetische Biologie?

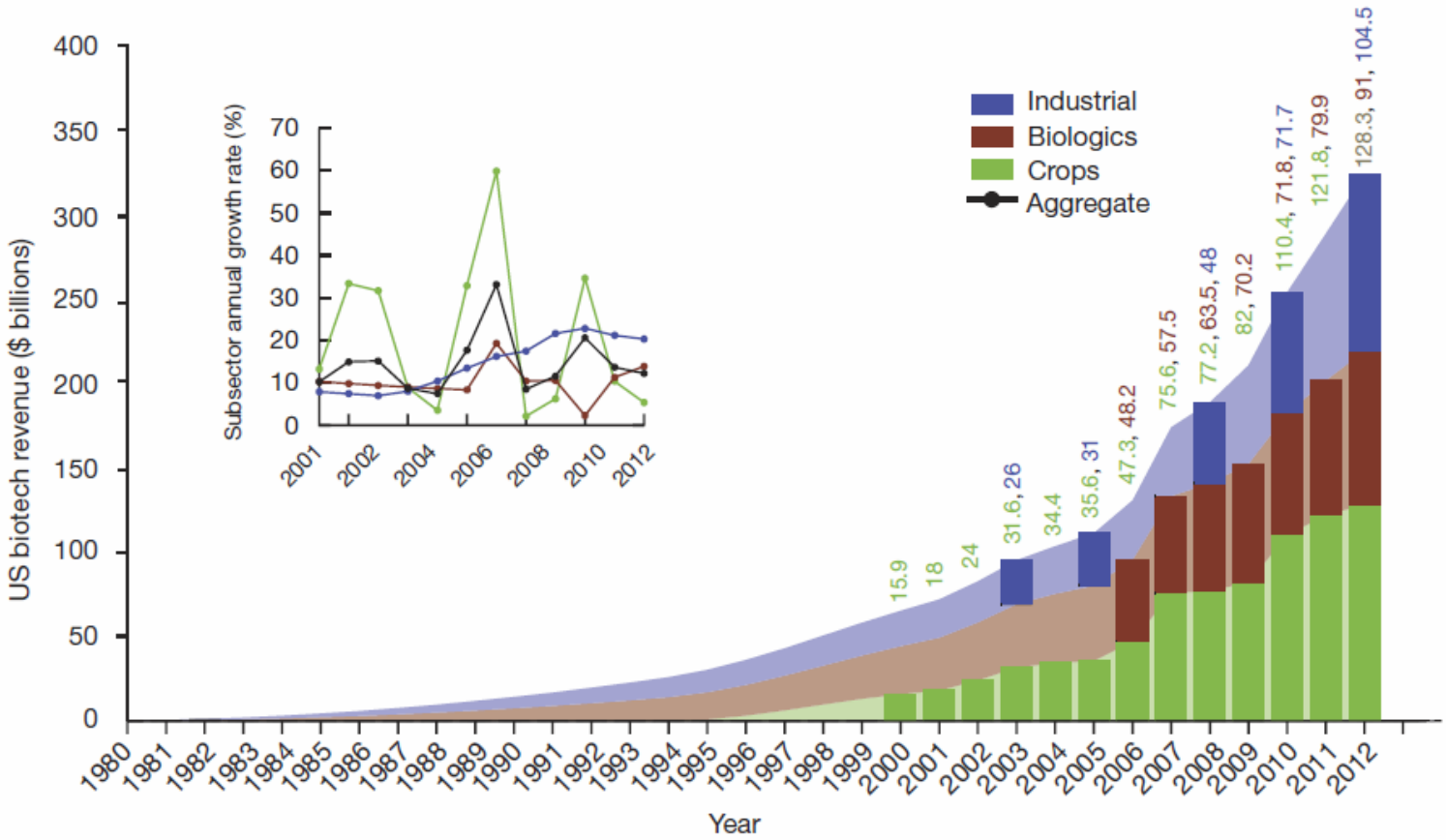
synthetische Biologie

Synthetische Biologie – die Anwendung von Wissenschaft und Technik um genetisches Material in lebenden Organismen zu entwickeln, erzeugen und/oder zu verändern



http://www.synthetic-bestiary.com/tag/synthetic-biology/

synthetische Biologie



Carlson Nature 2016

synthetische Biologie

Anwendung heute:

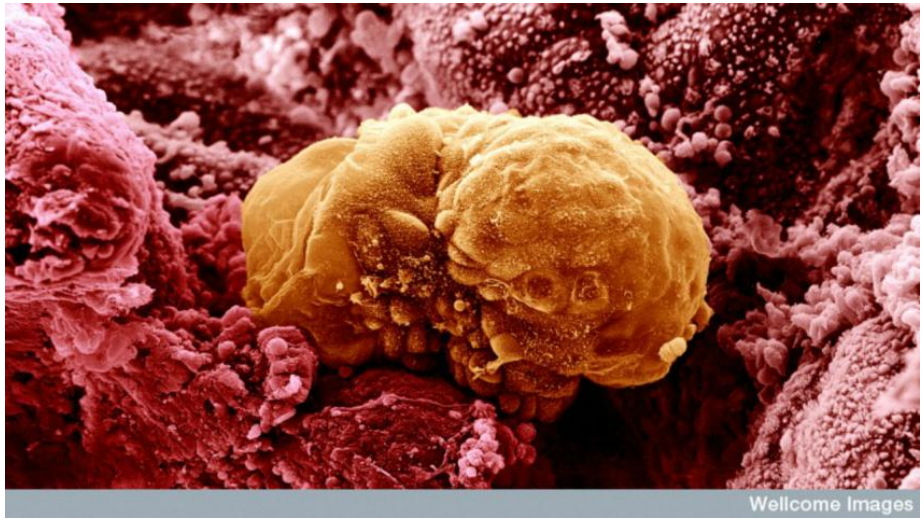
Geschmacksstoffe, Düfte Pharmaka, Textilien, Chemikalien,

im Labor:
Feldfrüchte, Insekten, Tiere

Forschung

-> Gentherapie an Stammzellen beim Menschen (e.g. National Academy of Sciences, 2015),

-> menschliche Embryonenforschung (UK)



Naturschutzbiologie

Naturschutzbiologie – “Krisendisziplin” untersucht biologische Vielfalt um Arten, Lebensräume und Ökosysteme vor dem Aussterben zu schützen (1978)

https://www.conservationjobsuk.com/conservation-biology-jobs.cms.asp

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PNAS

Opinion: Is CRISPR-based gene drive a biocontrol silver bullet or global conservation threat?

Bruce L. Webber[a,b], S. Raghu[c], and Owain R. Edwards[a,1]

Cheating evolution: engineering gene drives to manipulate the fate of wild populations

Animal Conservation

ZSL LET'S WORK FOR WILDLIFE

Animal Conservation. Print ISSN 1367-9430

EDITORIAL

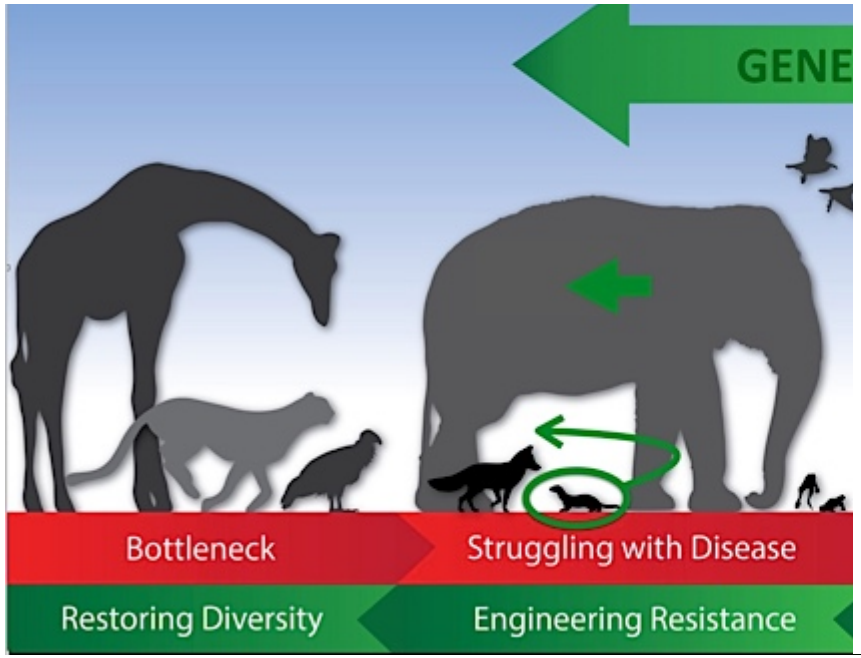
Is there a future for genome-editing technologies in conservation?

J. A. Johnson[1], R. Altwegg[2], D. M. Evans[3], J. G. Ewen[4], I. J. Gordon[5], N. Pettorelli[4] & J. K. Young[6]

De – Extinction

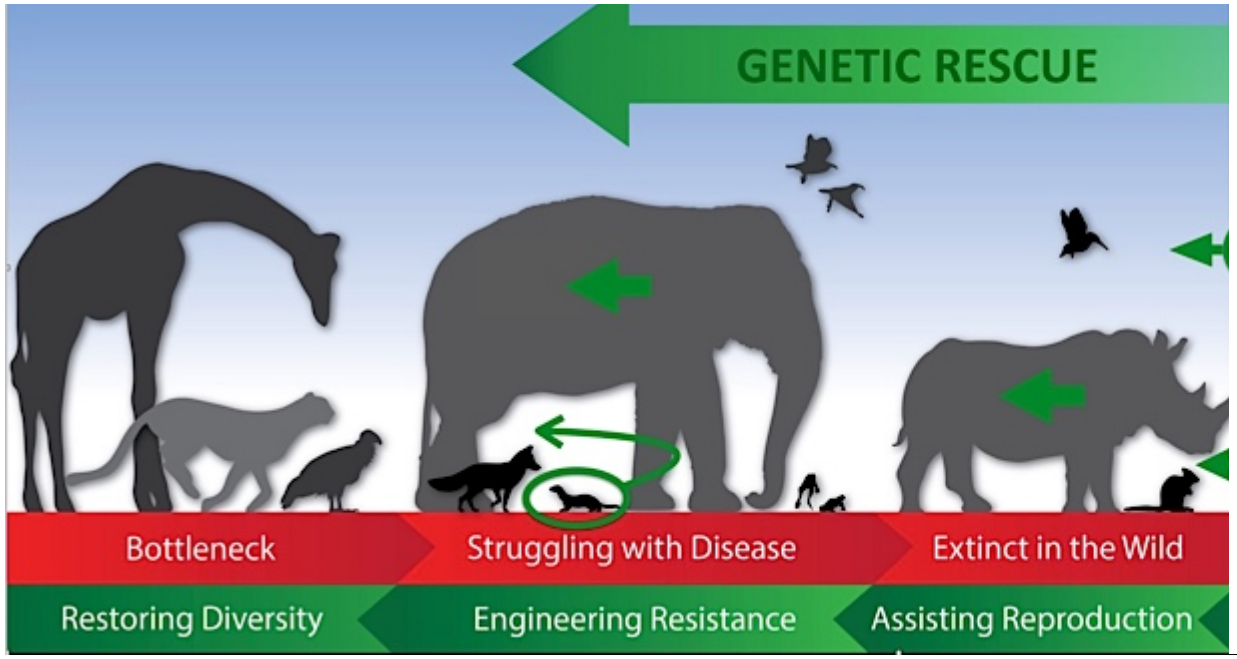
http://reviverestore.org/annual-report/#2016AnnualReport

De – Extinction



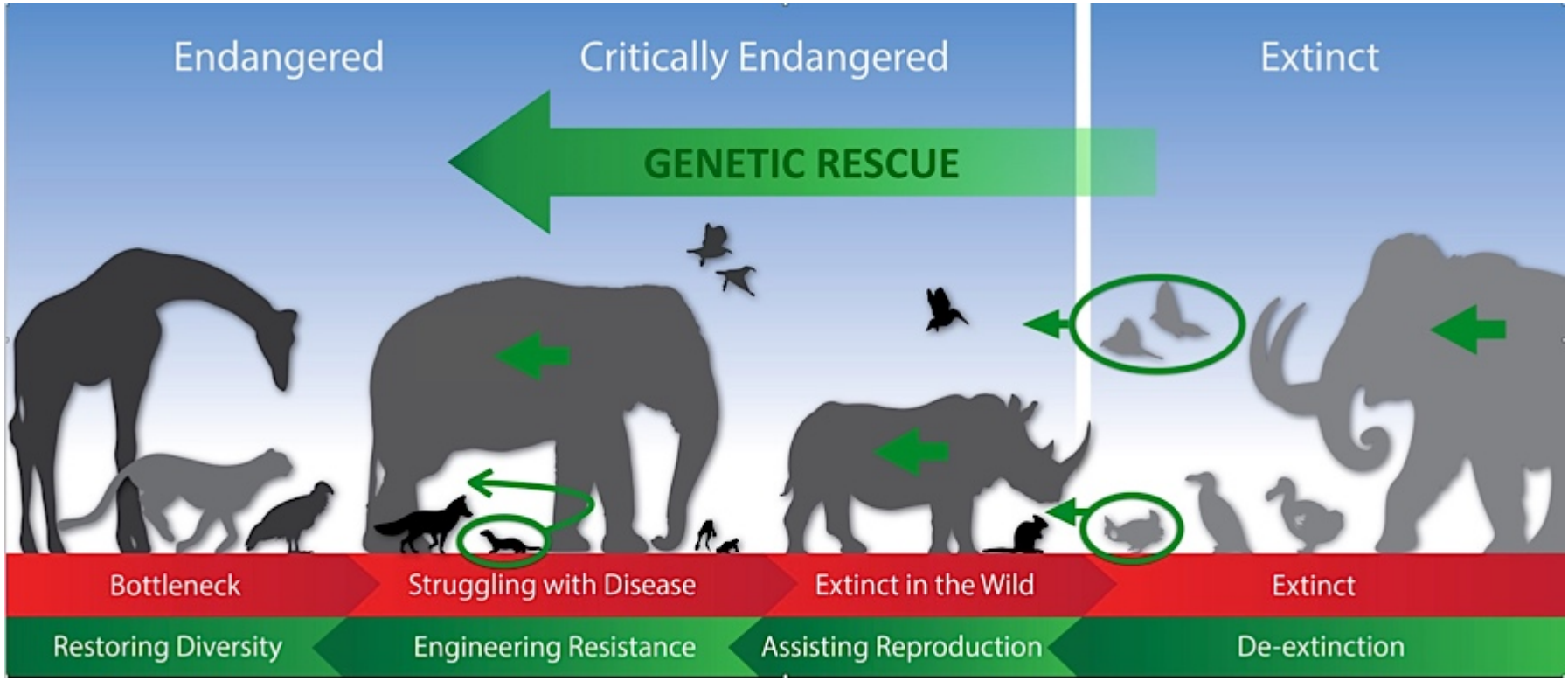
http://reviverestore.org/annual-report/#2016AnnualReport

De – Extinction



http://reviverestore.org/annual-report/#2016AnnualReport

De – Extinction



http://reviverestore.org/annual-report/#2016AnnualReport

Herausforderungen

Synthetische Biologie und die Biodiversitätskonvention (CBD)

Fünf Schlüsselentscheidungen für die COP 13 und die COP-MOP 8

https://www.boell.de/sites/default/files/synthetische-biologie-und-die-biodiversitaetskonvention-cbd.pdf

Ethische Herausforderungen

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EMBO reports

Science & Society

No time to waste—the ethical challenges created by CRISPR

CRISPR/Cas, being an efficient, simple, and cheap technology to edit the genome of any organism, raises many ethical and regulatory issues beyond the use to manipulate human germ line cells

Arthur L Caplan[1], Brendan Parent[1], Michael Shen[2] & Carolyn Plunkett[1,3]

BIOETHICS

Embryo engineering study splits scientific community

First test of gene-editing technique on human embryos illustrates clinical risks

By **Jocelyn Kaiser** *and* **Dennis Normile**

the CRISPR-Cas9 system, a new technology

Zukunft

Wahl:

Handeln oder nicht handeln

genetic -> genomic -> synthetic

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genetic -> genomic -> synthetic

Interaktionen zwischen Forschungsfeldern früh wichtig

genetic -> genomics -> synthetic

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Wir sollten

- eng mit synthetischen Biologen zusammenarbeiten
- Fallstudien sorgfältig auswählen
- Verantwortung übernehmen

und gleichzeitig Gebiete unbeeinflusst lassen

ist das Genom die neue Wildnis?

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ist das Genom die neue Wildnis?

TREE 2184 No. of Pages 11 ARTICLE IN PRESS

Trends in Ecology & Evolution CellPress

Opinion

Is It Time for Synthetic Biodiversity Conservation?

Antoinette J. Piaggio,[1,17,*] Gernot Segelbacher,[2,17] Philip J. Seddon,[3,17] Luke Alphey,[4,5] Elizabeth L. Bennett,[6] Robert H. Carlson,[7] Robert M. Friedman,[8] Dona Kanavy,[9] Ryan Phelan,[10] Kent H. Redford,[11,12] Marina Rosales,[13] Lydia Slobodian,[14] and Keith Wheeler[15,16]