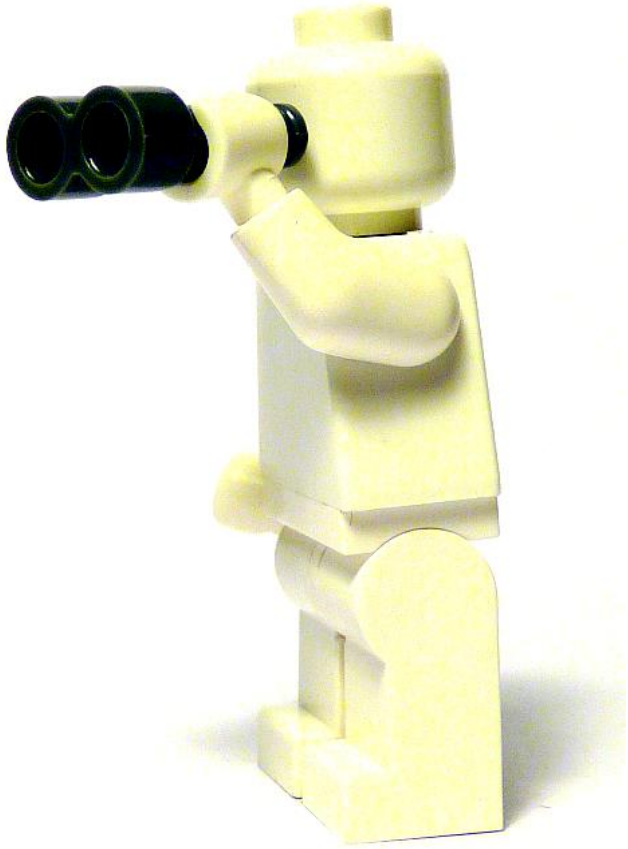
An Introduction to

Synthetic Biology –

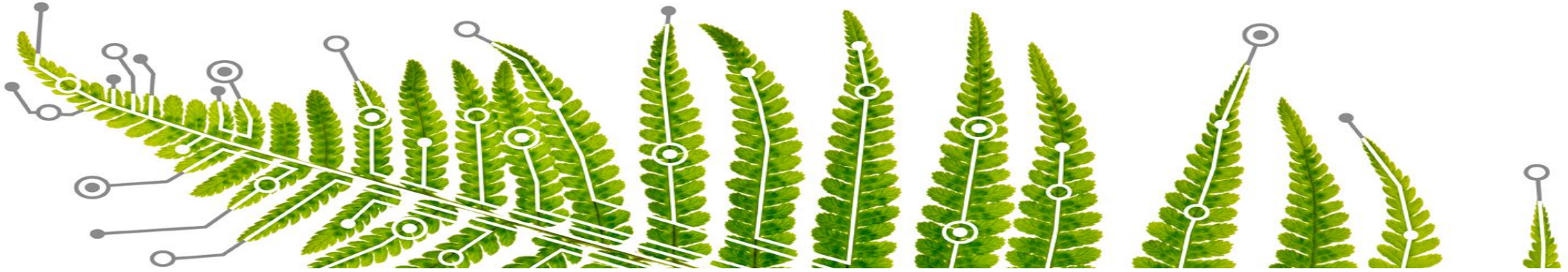
Jim Thomas – ETC Group www.etcgroup.org

etc GROUP

monitoring power
tracking technology
strengthening diversity



“Technology Watchdog”



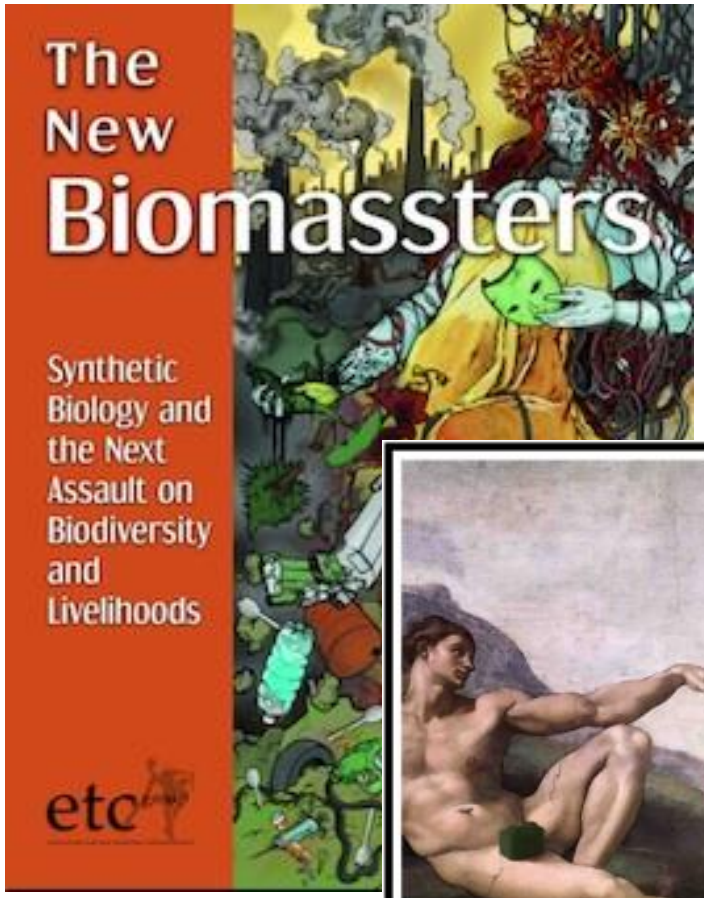
Tracking

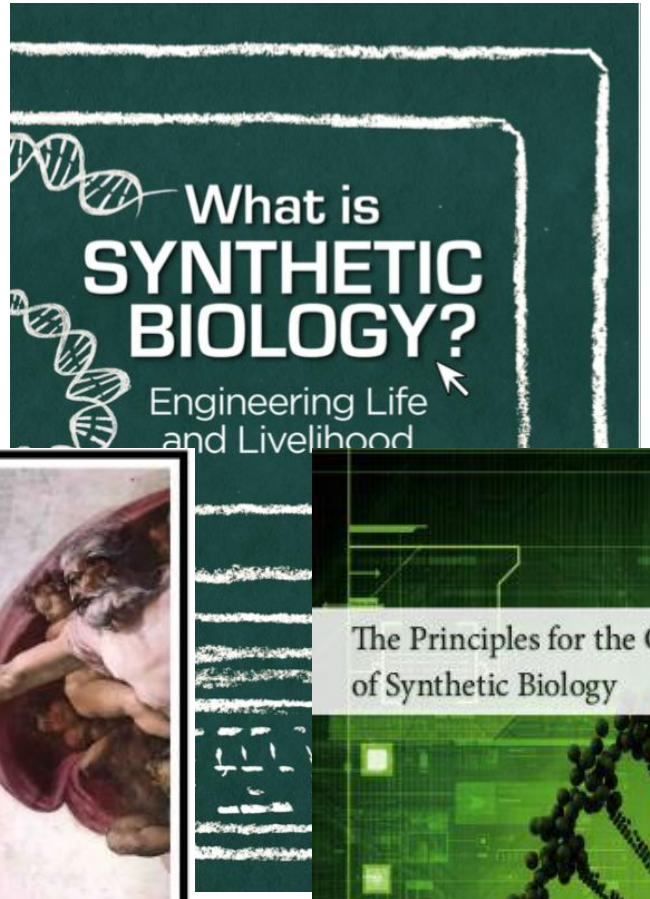
Emerging Technologies

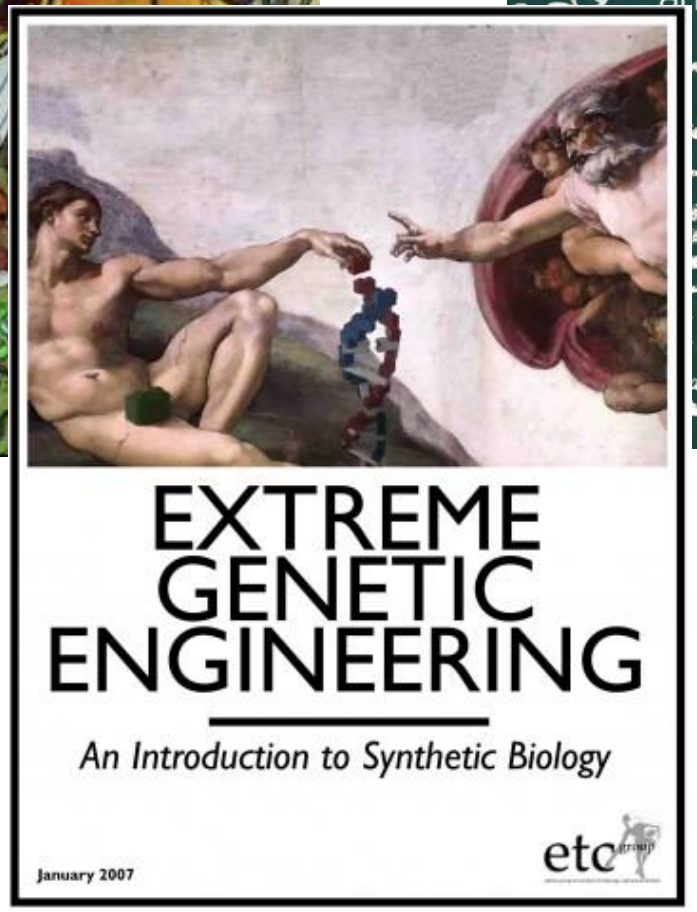
And Corporate Concentration

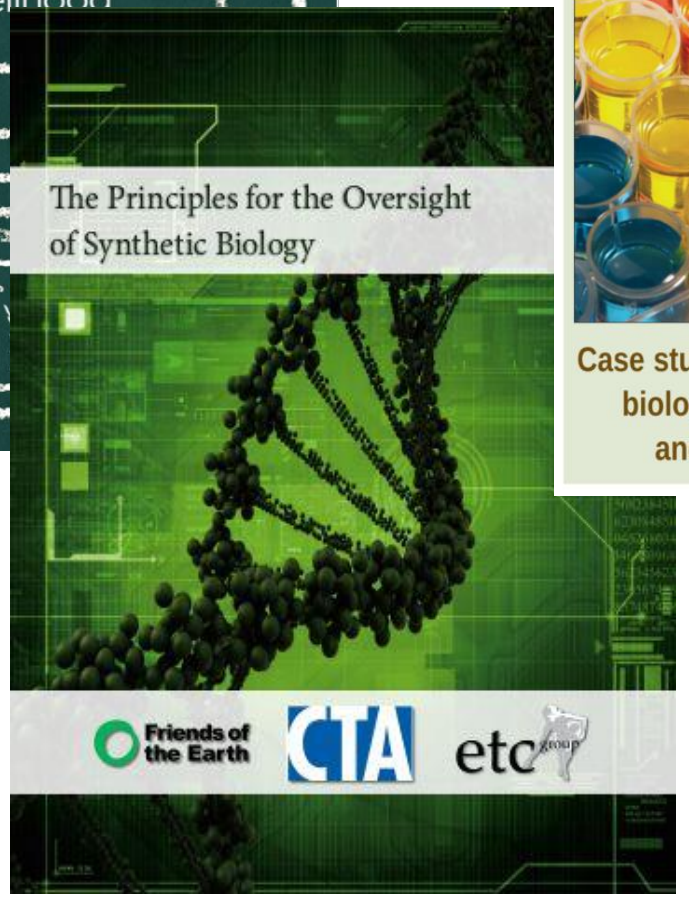
…on behalf of

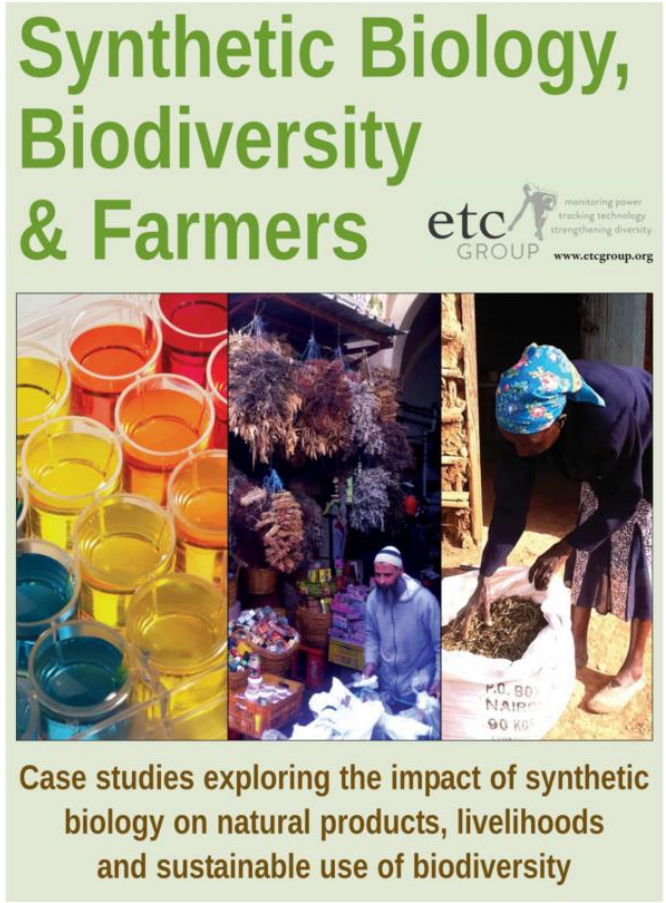
marginalised people.

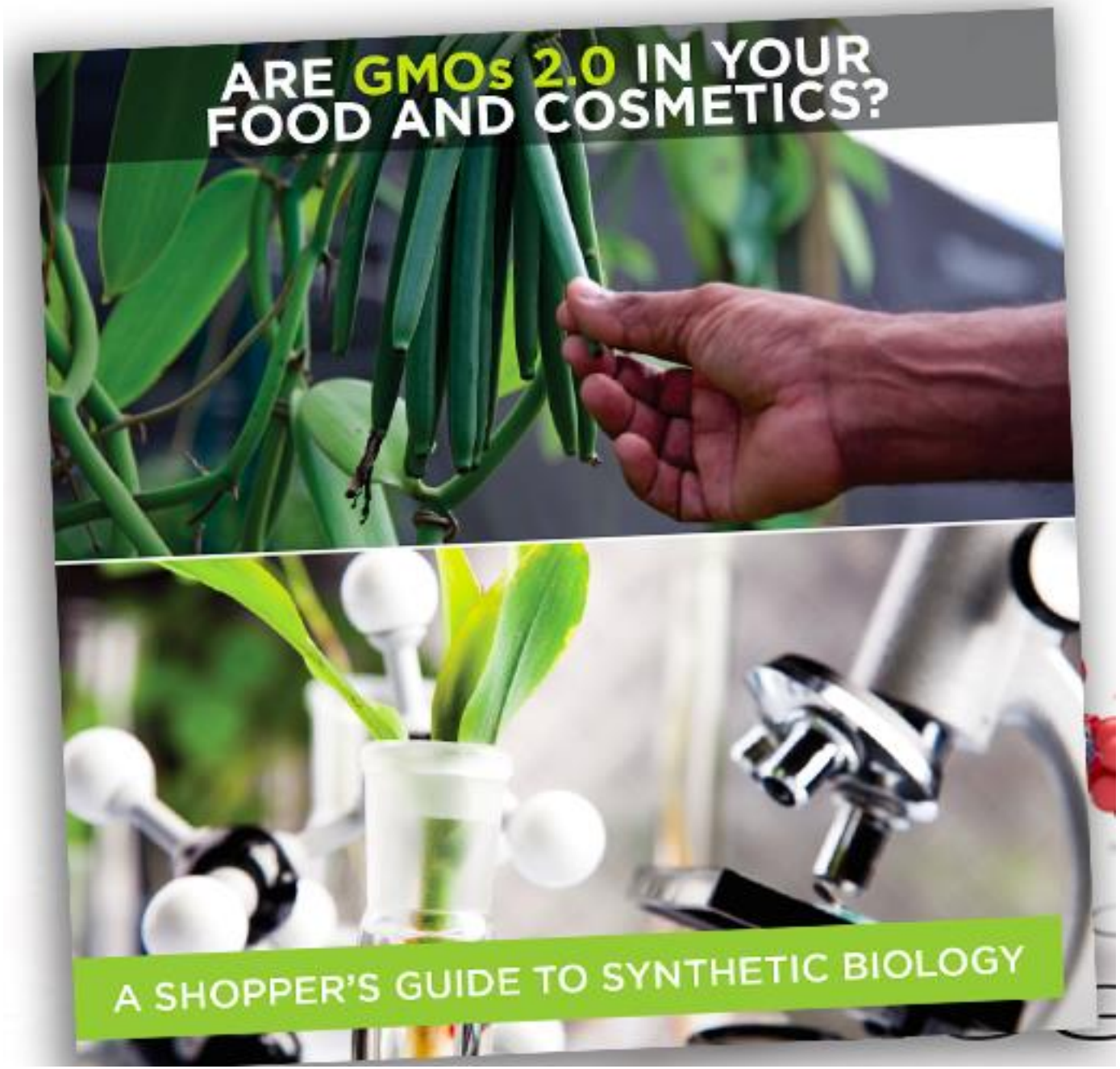

The New
Biomassters
Synthetic Biology and the Next Assault on Biodiversity and Livelihoods
etc


What is
SYNTHETIC BIOLOGY?
Engineering Life and Livelihood


EXTREME GENETIC ENGINEERING
An Introduction to Synthetic Biology
January 2007
etc group


The Principles for the Oversight of Synthetic Biology
Friends of the Earth
CTA
etc group

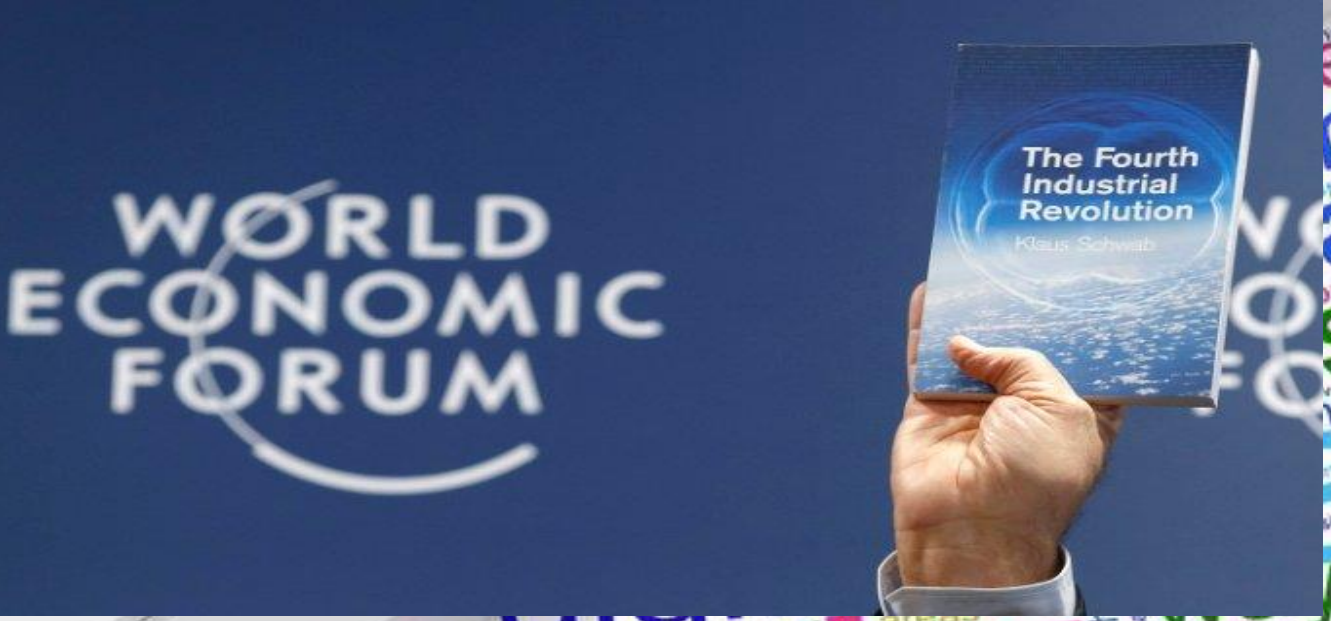

Synthetic Biology, Biodiversity & Farmers
etc GROUP
monitoring power
tracking technology
strengthening diversity
www.etcgroup.org
Case studies exploring the impact of synthetic biology on natural products, livelihoods and sustainable use of biodiversity


ARE GMOs 2.0 IN YOUR FOOD AND COSMETICS?
A SHOPPER'S GUIDE TO SYNTHETIC BIOLOGY

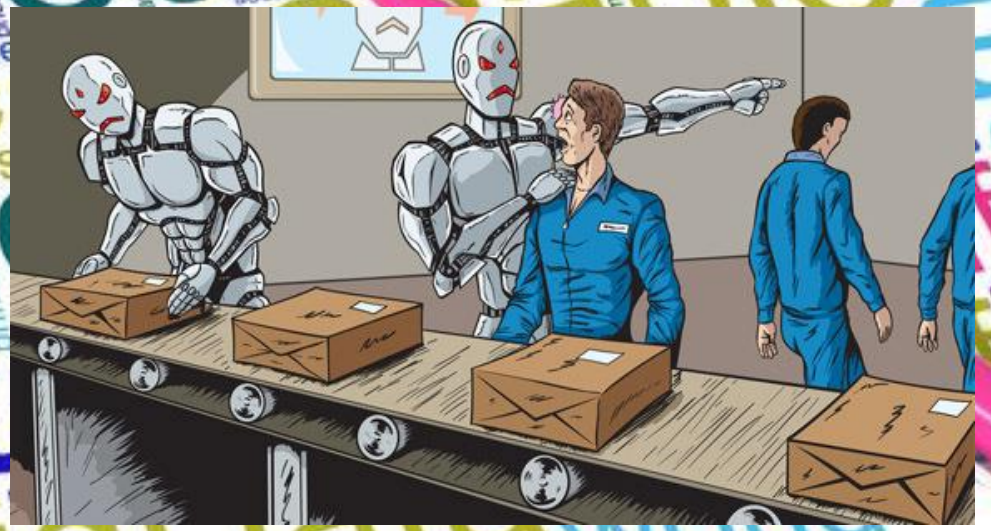
And Supplements??!

SUSTAINABLE DEVELOPMENT GOALS

17 GOALS TO TRANSFORM OUR WORLD


WORLD
ECONOMIC
FORUM
The Fourth
Industrial
Revolution
Klaus Schwab

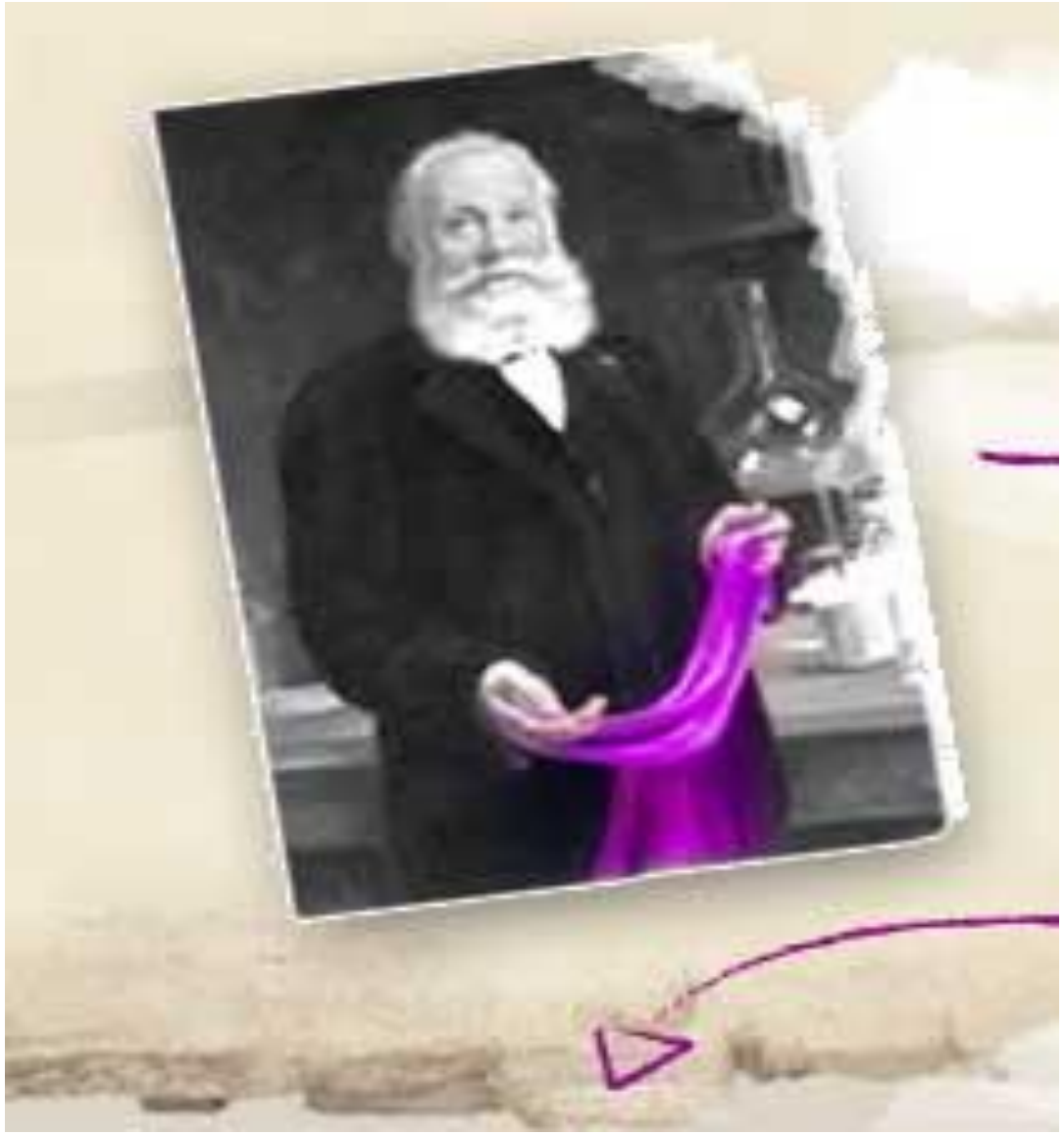

DATA
Ai
IoT



What does 4th Industrial Revolution mean for Natural Products?


CHANGE
AHEAD

Historical Snapshot 1



160 years of ‘Syn Bots’

June 1857 - William Henry Perkin builds factory to manufacture synthetic mauvine.

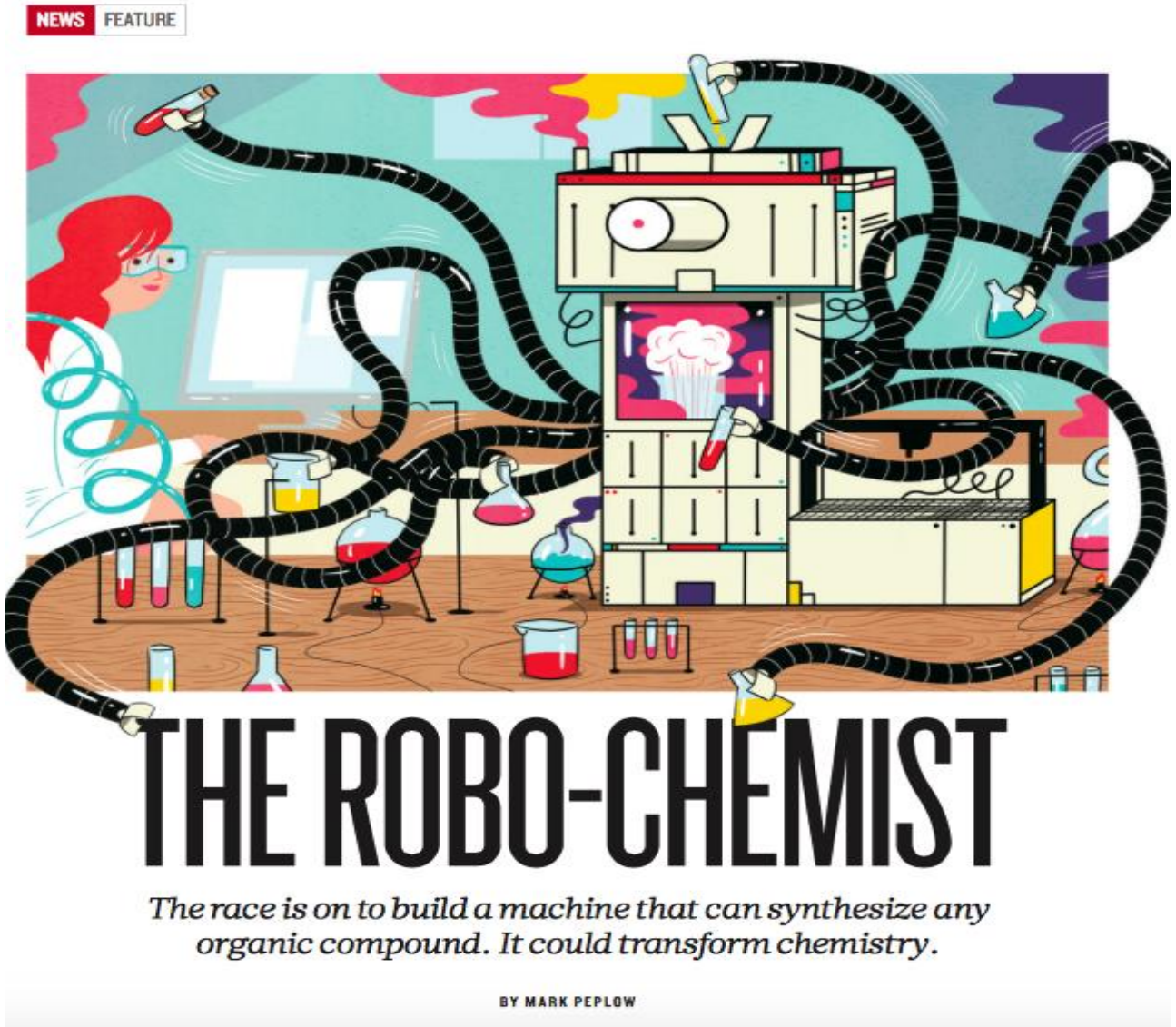
160 years of ‘Syn Bots’

Synthetic Indigo (Bayer) - 1897

Bengal Famine – 1943


GRANA COCHINILLA
Dactylopius
costa

- **Computer Assisted Organic Synthesis (CAOS)** ,

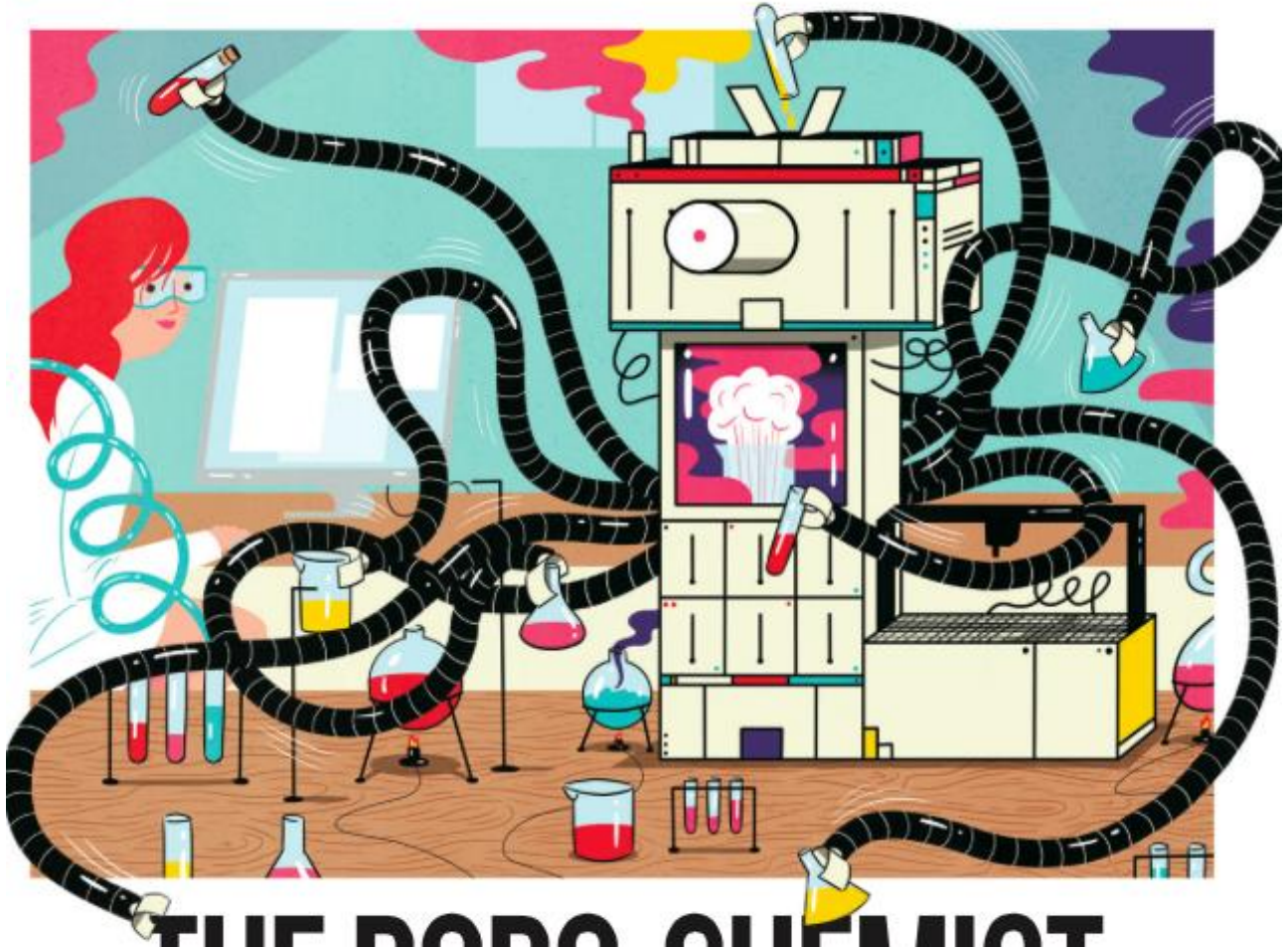


"A **SYNTHESIS MACHINE** COULD MAKE ANY OF **A BILLION** DEFINED SMALL MOLECULES **ON DEMAND**."

"A growing band of chemists is now trying to free the field from its artisanal roots by creating a device with the ability to fabricate any organic molecule automatically …

… Such a device could thus offer an astonishing diversity of compounds for investigation by researchers developing drugs, agrochemicals or materials. "

NEWS FEATURE



THE ROBO-CHEMIST

The race is on to build a machine that can synthesize any organic compound. It could transform chemistry.

BY MARK PEPLOW

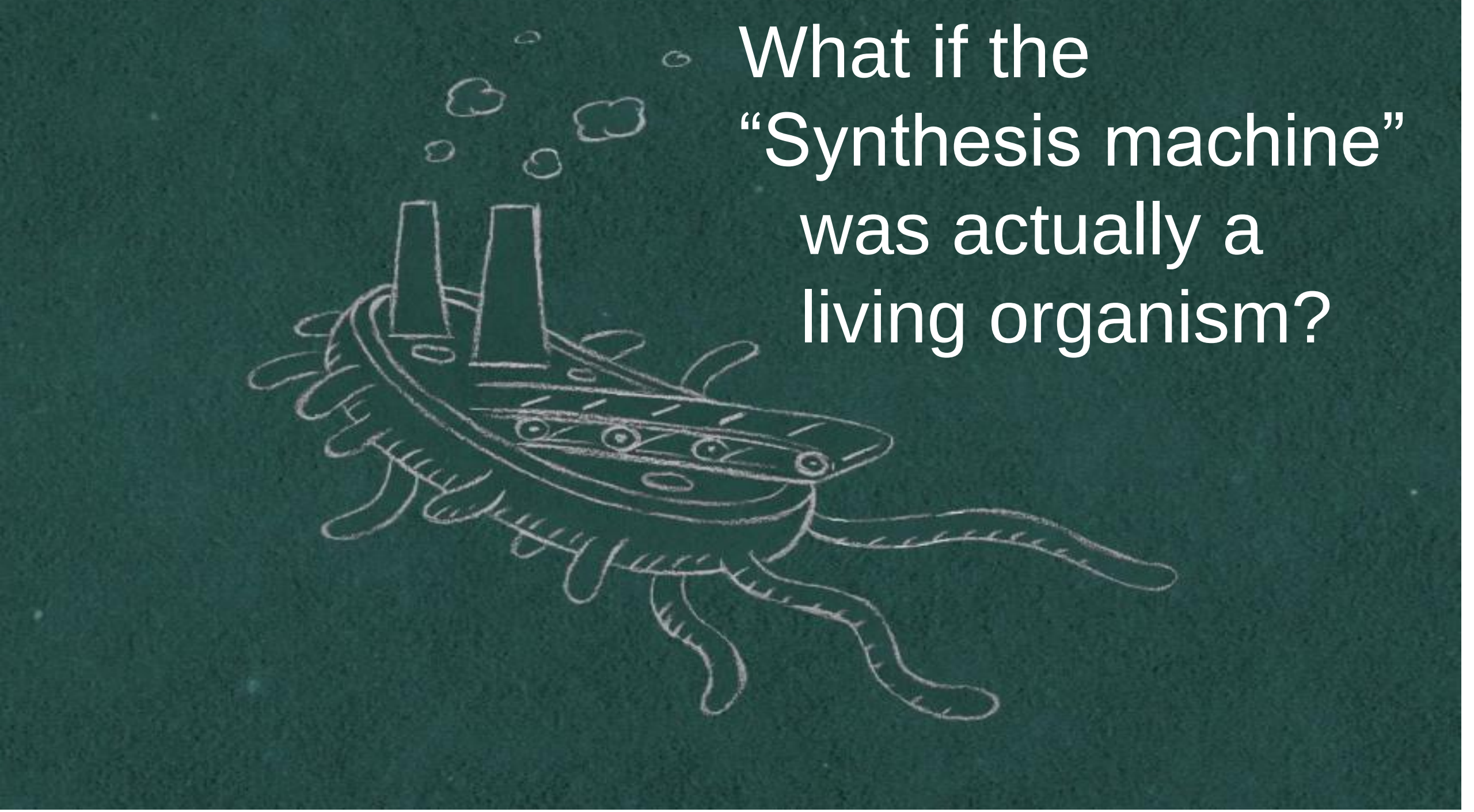
- **Dial-a-molecule consortium** (Nottingham, UK)

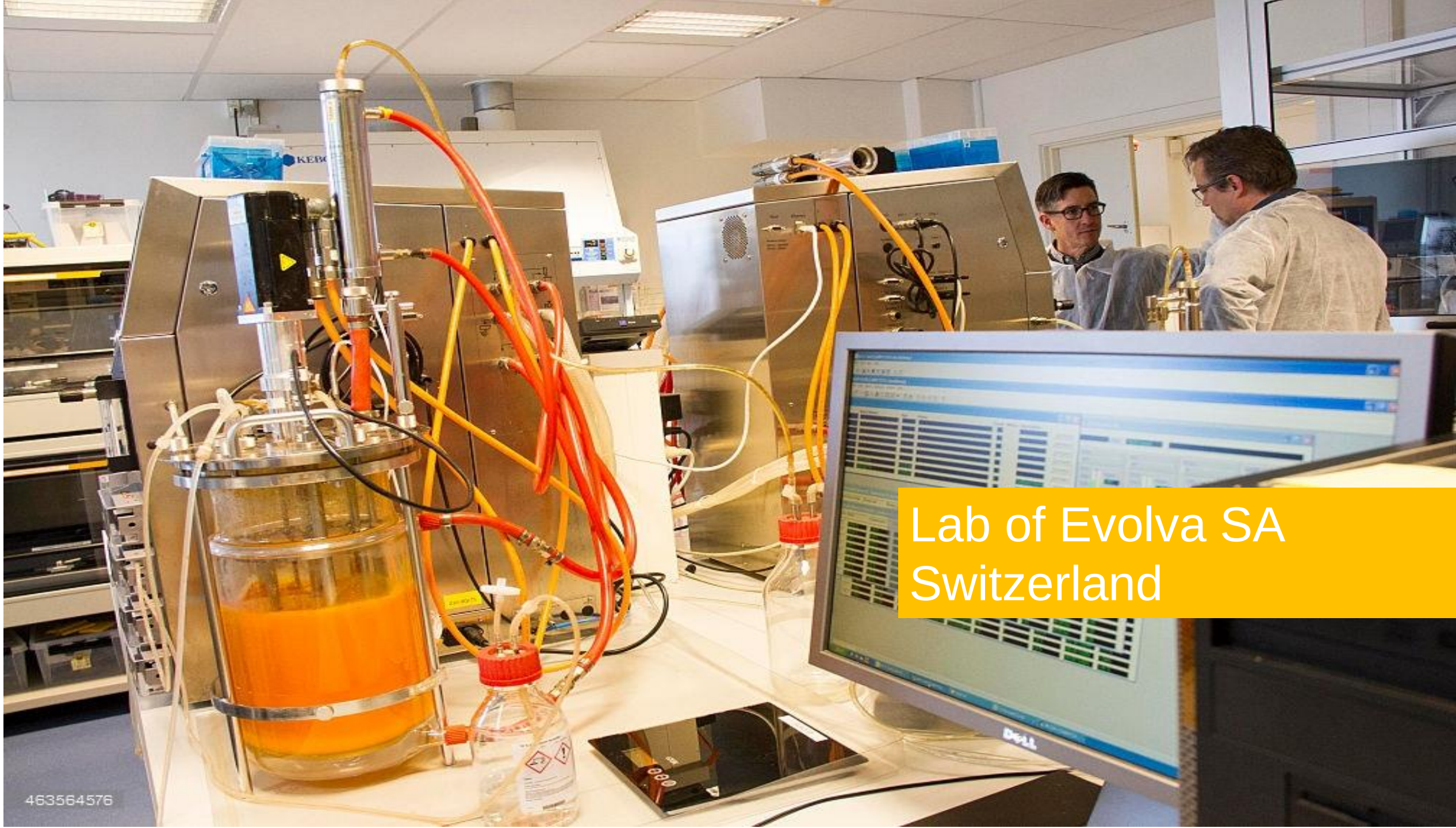
- a collaboration of more than 450 researchers and 60 companies

“In 20-40 years, scientists will be able to deliver any desired molecule within a timeframe useful to the end-user, using safe, economically viable and sustainable processes. “

- **Chematica**

Big Data screening of huge chemical databases. Works out cheaper more efficient routes to synthesis “In 5 seconds we can screen 2 billion possible synthetic routes,” - Bartosz Grzybowski, Northwestern University in Evanston, Illinois .


What if the
“Synthesis machine”
was actually a
living organism?


Lab of Evolva SA
Switzerland
463564576

Evolva – a yeast "metro" for valuable products

evolva

Ambergris

Pyrethrin

Caffeine

Opiates

Cocoa

Sandalwood

Stevia

Saffron

Musk

Frankincense

Caviar

Mint

Capsiate

Taxol

Vanilla

Dopamine

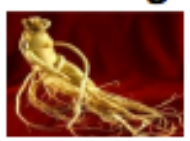
Resveratrol

Turmeric

Carmine

Breast Milk

Ginseng



Truffles

"Any compound produced by a plant, we can now make inside a microbe"

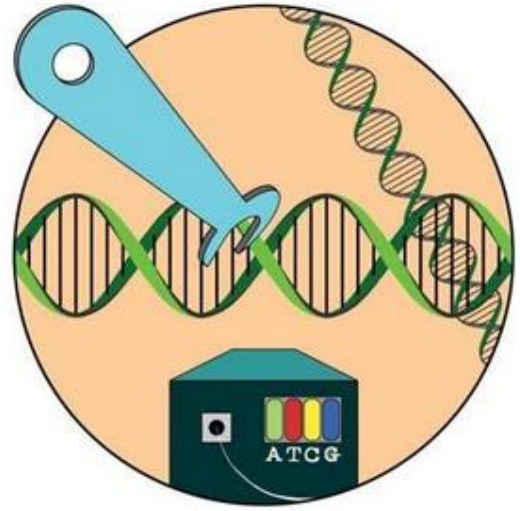
Jay Keasling (Synthetic Biologist)

It’s broadly defined:

NEXT GENERATION GENETIC ENGINEERING

“Synthetic Biology is a ***further development and new dimension of modern biotechnology*** *that combines science, technology and engineering to facilitate and accelerate the understanding,* ***design, redesign, manufacture and/or modification of genetic materials , living organisms and biological systems***”

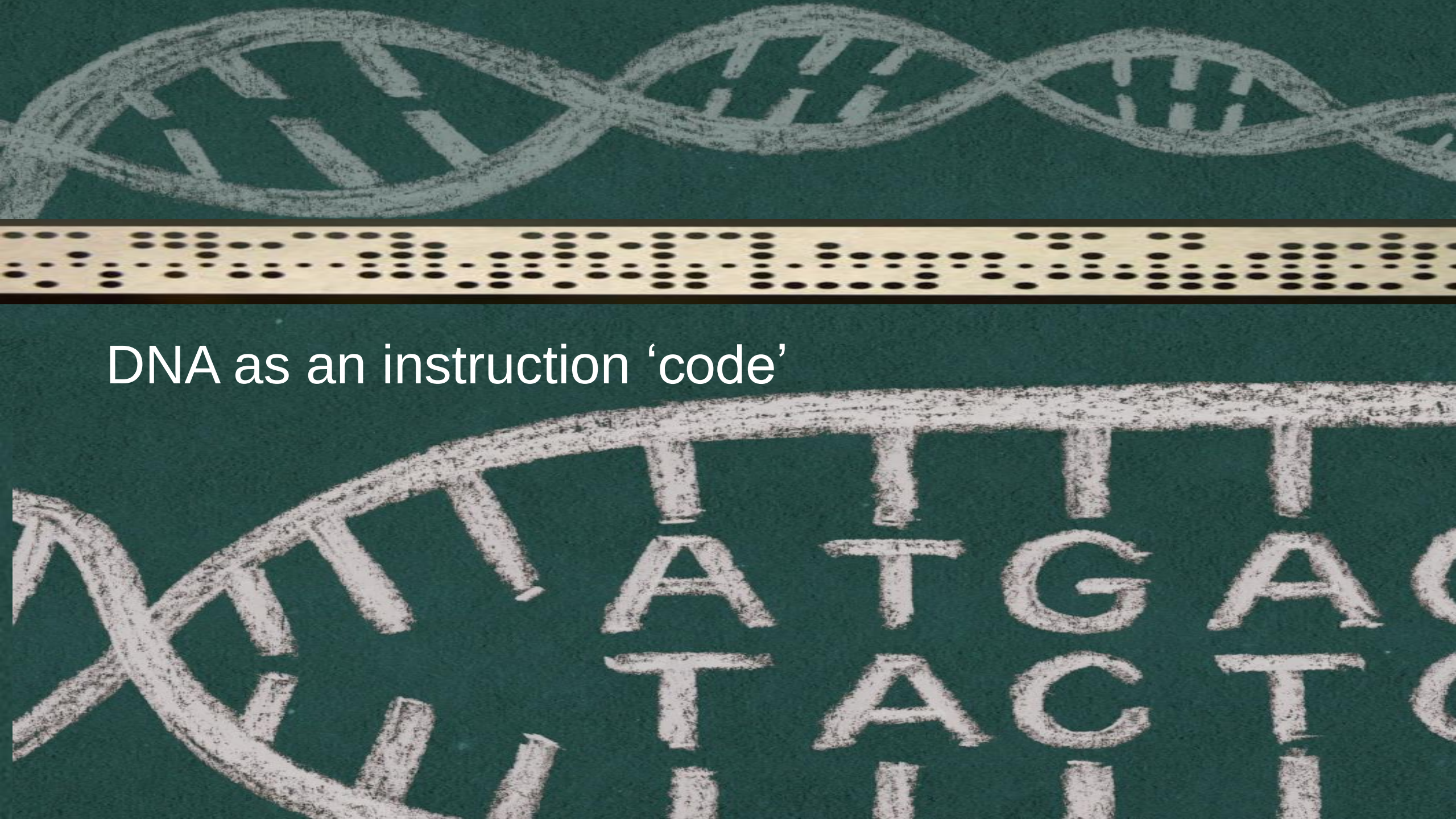
- Operational definition adopted by the UN Convention on Biological Diversity COP13, Cancun - December 2016.



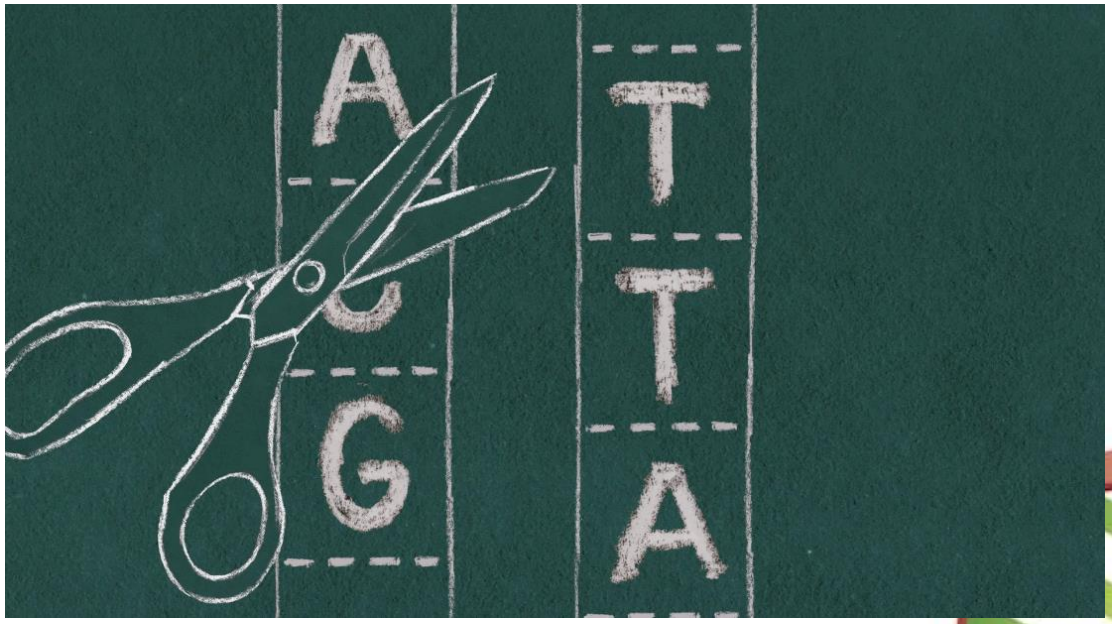

“Genetic Engineering ain’t what it used to be”

GMO 1.0
Transgenics

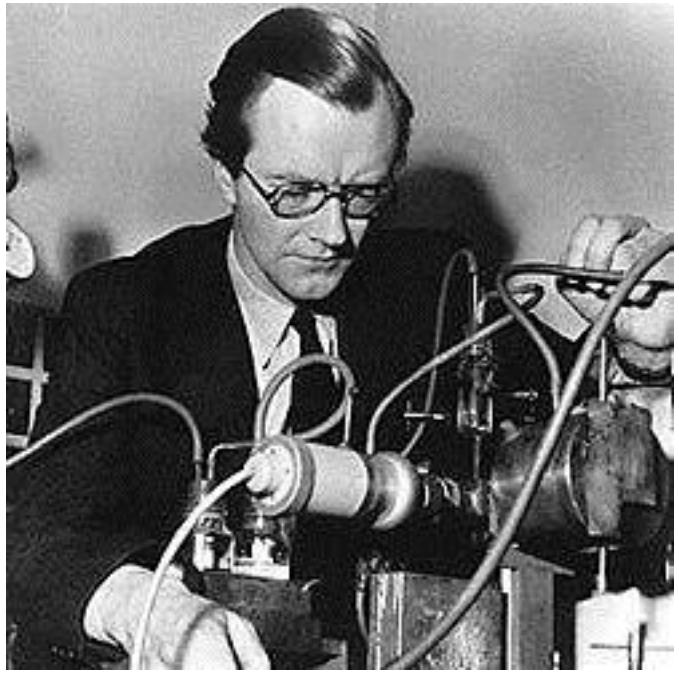
DNA as an instruction ‘code’

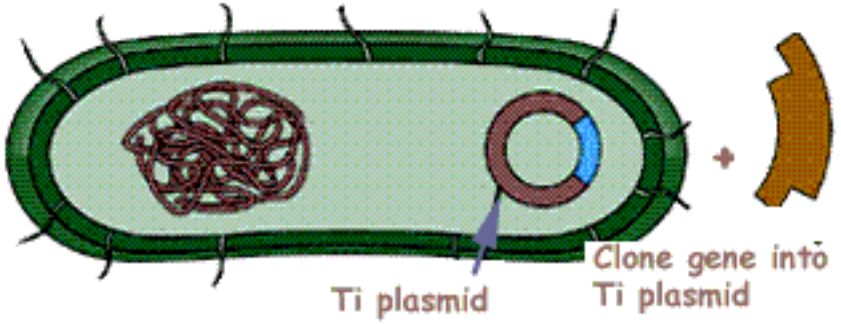


Changing the code back then…



Changing the code back then…





GMO’s 1.0 – two techniques plus only a handful of products.

This is now…

Genome READING

2015 Study: 2,500 high-throughput instruments, located in nearly 1,000 sequencing centers in 55 countries

PLoS Biol. 2015 Jul; 13(7): Stephens et al "**Big Data: Astronomical or Genomical?"**

Annual genomic data If 1 bp was a grain of sand…

2015: 35 petabases of genome sequencing (35 thousand trillion BP)
-32,000 microbial genomes, ~5,000 plant and animal genomes, and ~250,000 individual human genomes .

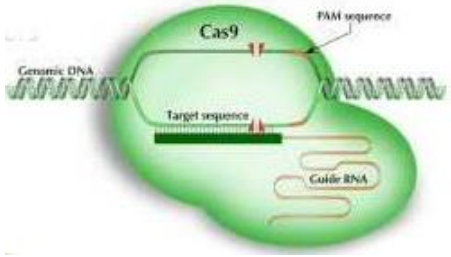
2025: 1 zetabase of genome sequencing (1 thousand million trillion BP).
Encompass All 1.2 million described species of plants and animals.
Estimated that there will be at least 2.5 million plant and animal genome sequences

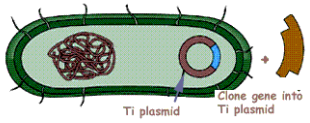
PLoS Biol. 2015 Jul; 13(7): Stephens et al "**Big Data: Astronomical or Genomical?"**

This is now…

GMO’s 2.0 – Wider toolbox of techniques,

This is now…

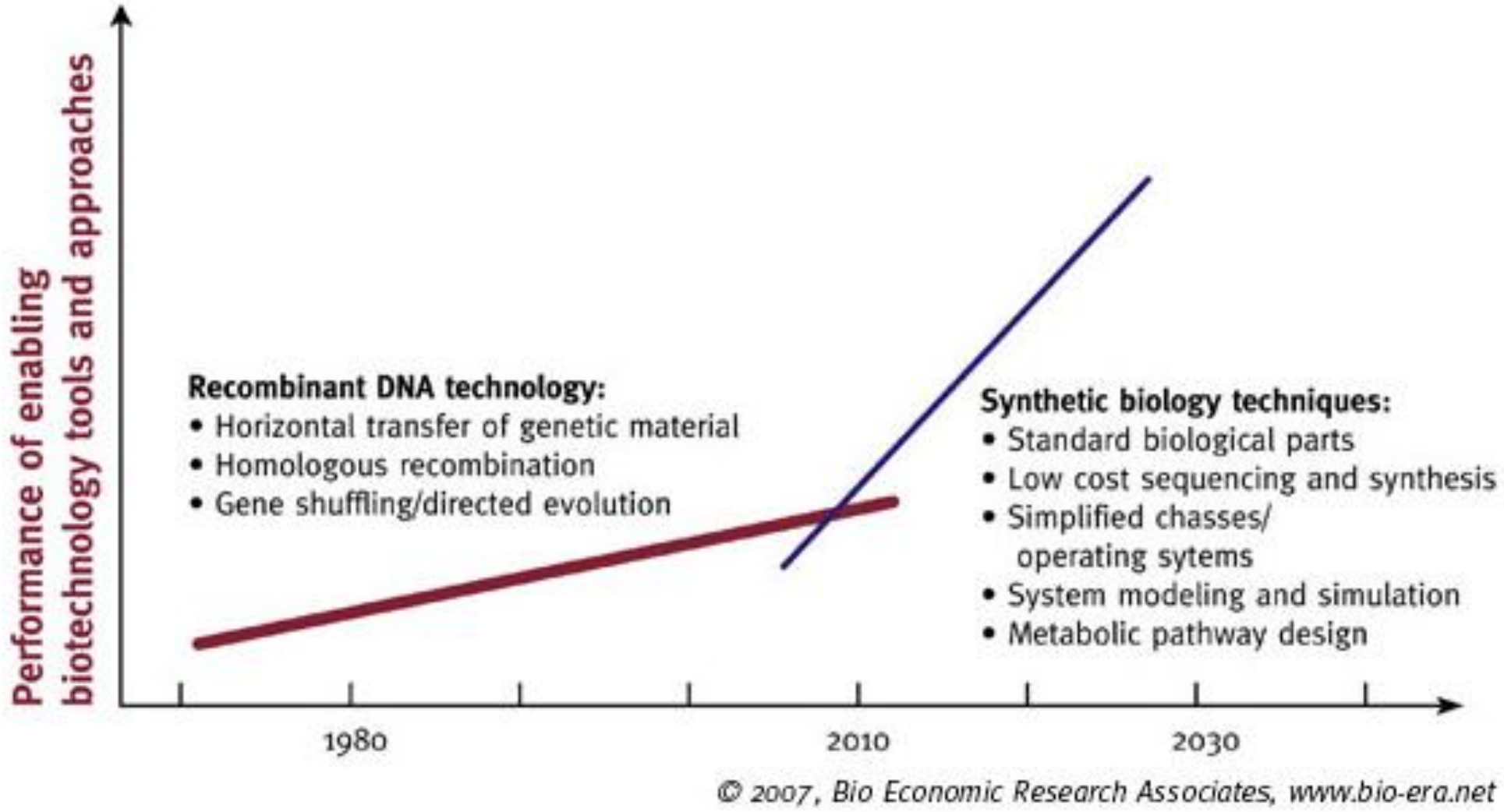




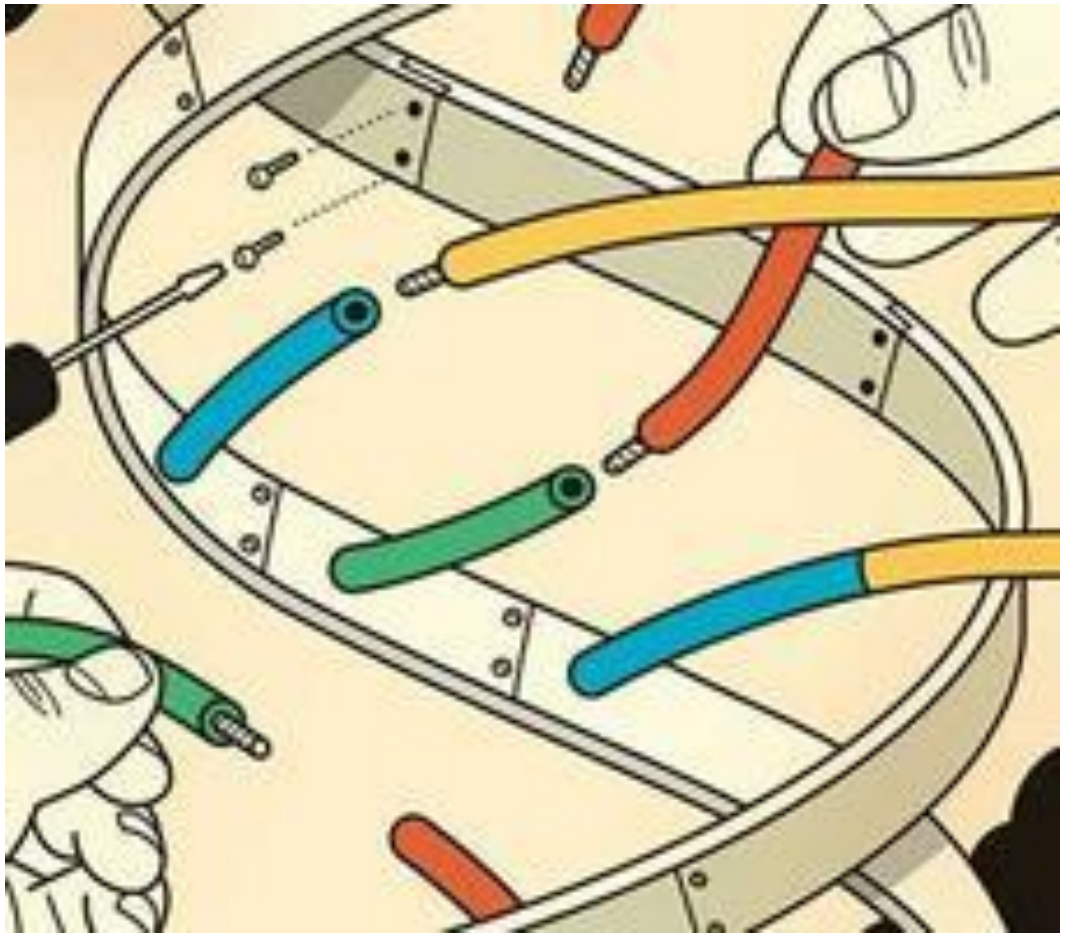
Clustered Regularly Interspersed Short Palindomic Repeats (CRISPR),
Directed Evolution,
DNA-based genetic circuits,
DNA Synthesis and Assembly,
Epigenetic Modification,
Expanded Genetic Alphabets,
Genome Editing,
Genome-level Engineering,
Genome Shuffling,
Gibson Assembly,
Minimal Genomes,
Multiplex Automated Genome Engineering,
Oligonucleotide Directed Mutagenesis,
Protocell Construction,
Refactoring of Genomes,
RNA-Directed DNA Methylation (RDDM).
RNAi (RNA Interference)
Standard Modular DNA ‘parts’ or ‘Biobricks’
Synthetic Metabolic Pathway Engineering,
Synthetic Genomics,
Transcription-Activator-like Effector Nucleases (TALENs),
Xenobiology,
Zinc Finger Nucleases(ZFN),

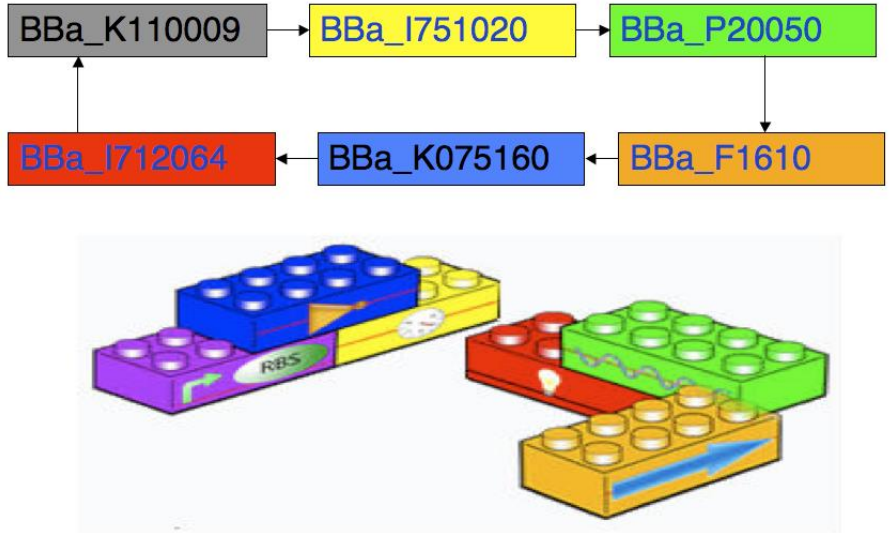
GMO 2.0: A step change.

Figure 1-2: *An Inflection Point for Biological Technology*

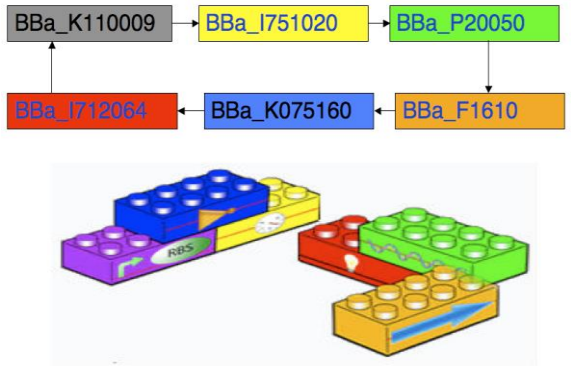


Making biology ‘**engineer-able**’

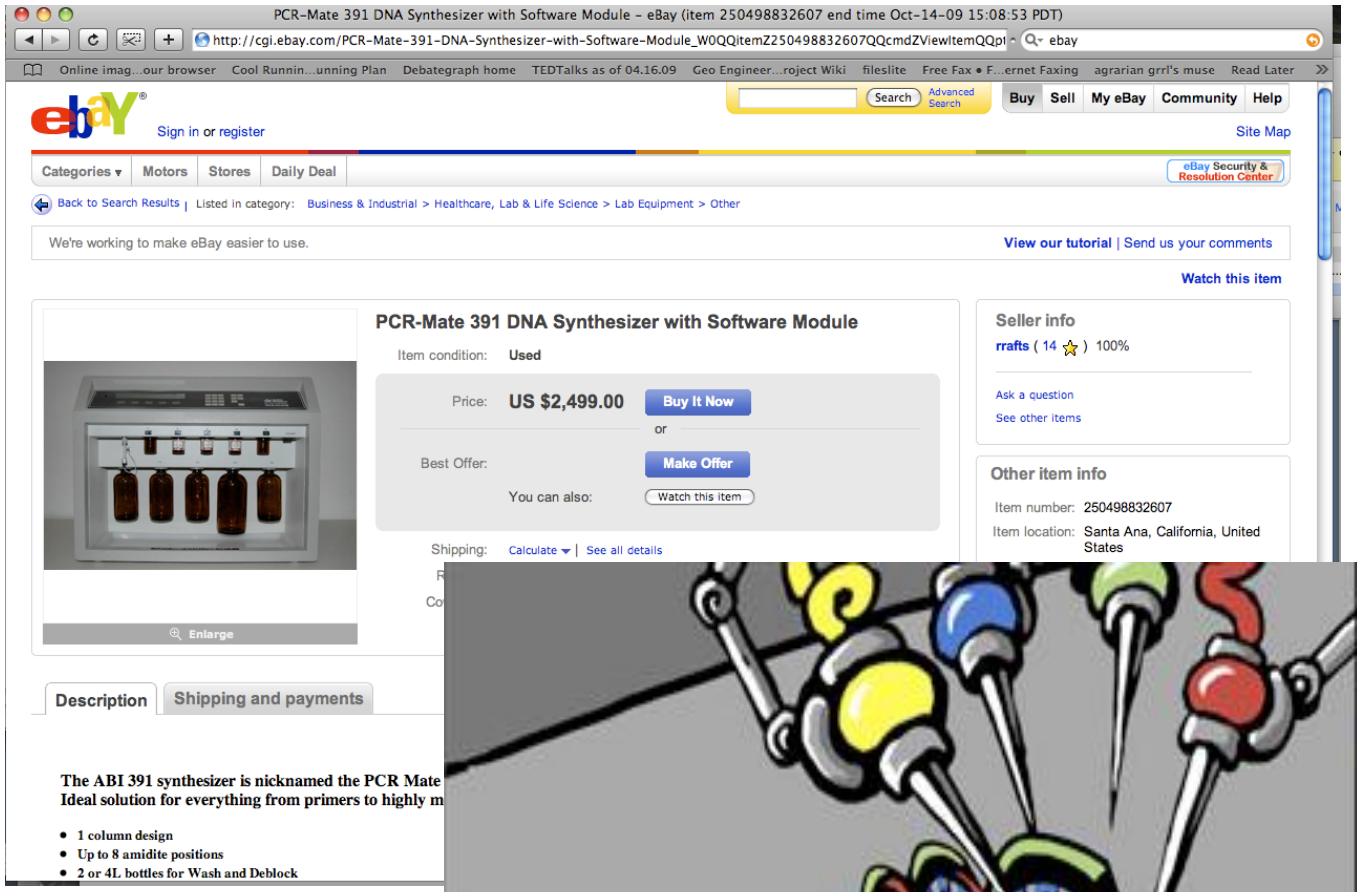


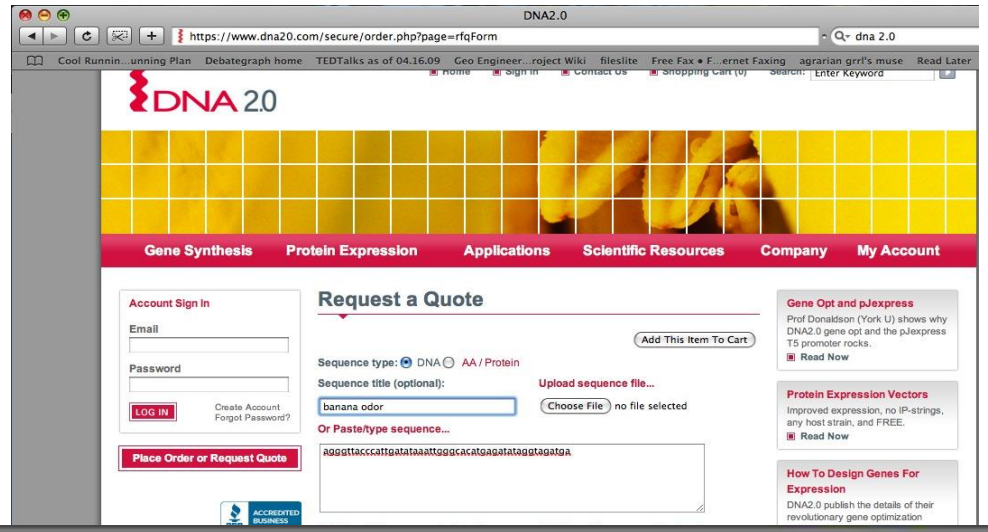


Making nature more “engineerable”:

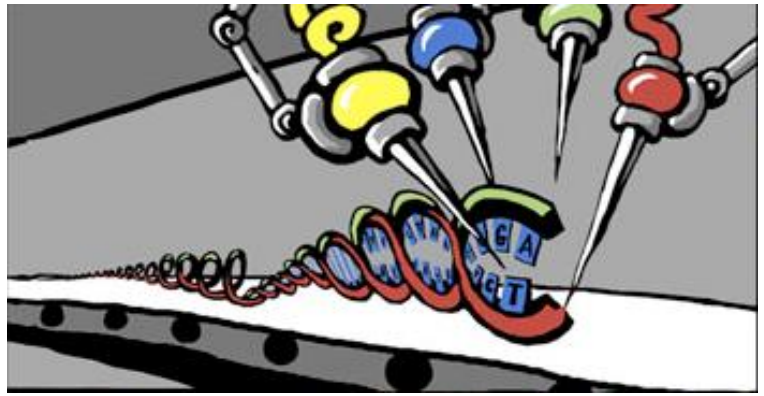


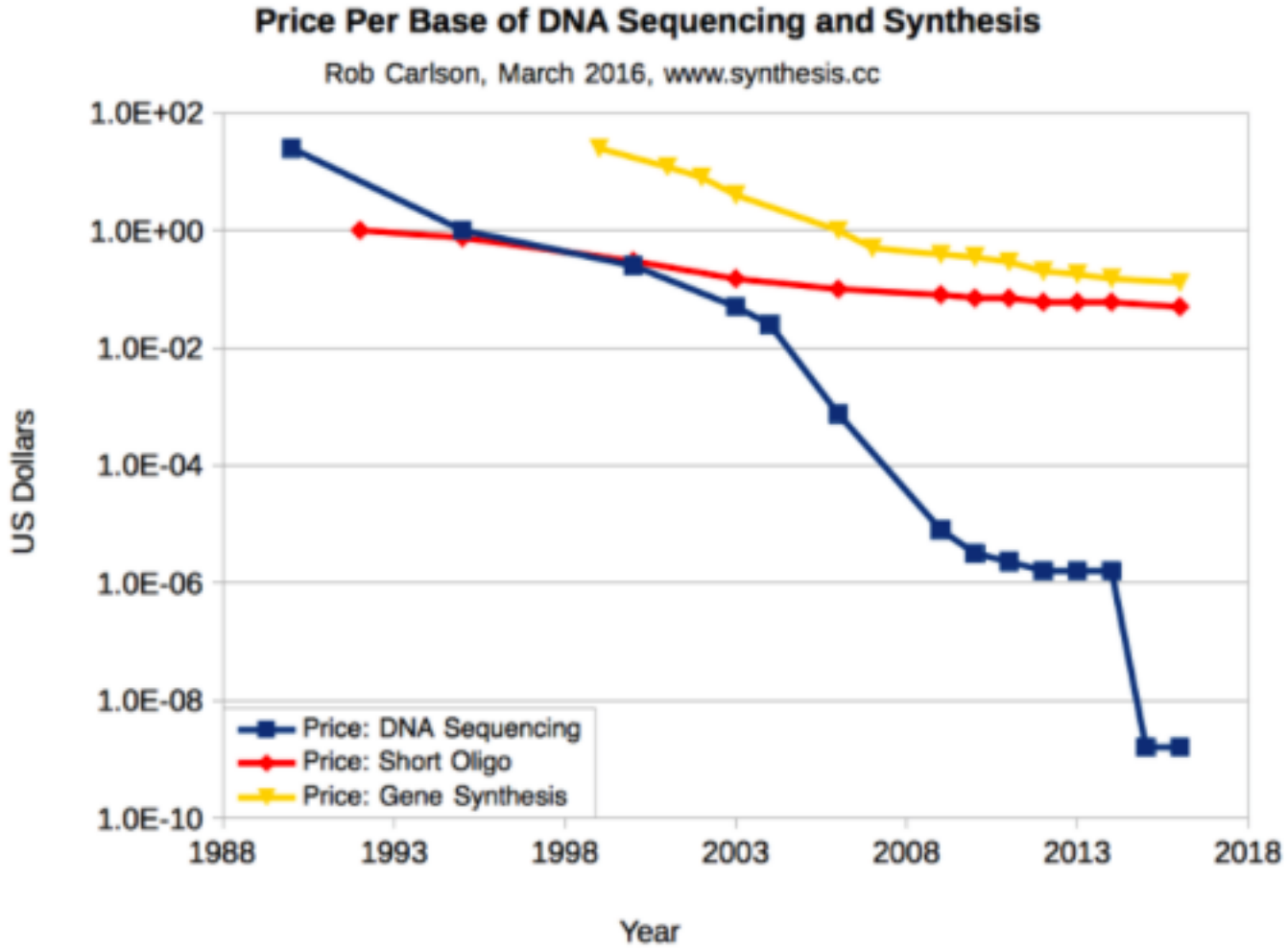
Synthesizing the parts of life





Genome WRITING

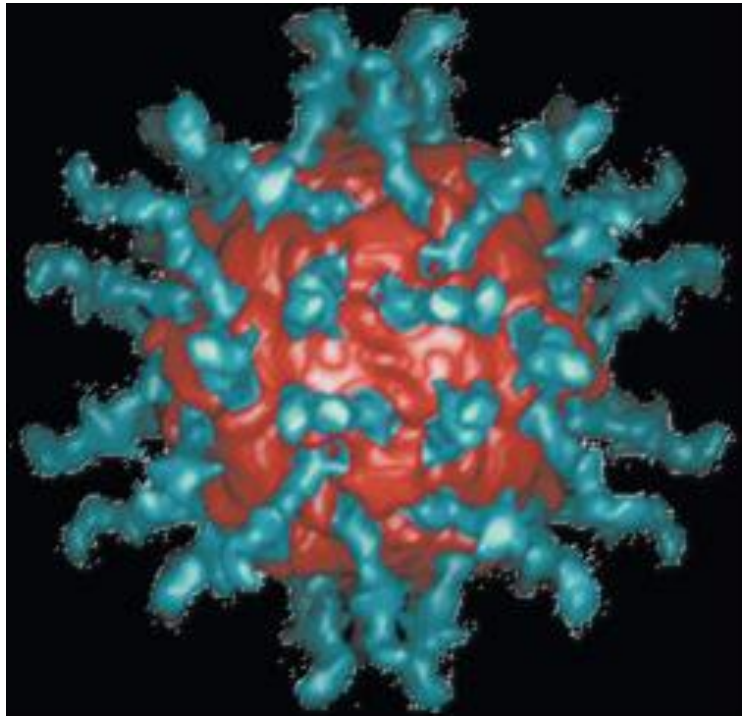




Commercial gene synthesis: 7- 17 cents per base Currently a billion base market – around a million genes.

Commercial Oligo Synthesis – 5 cents per base. Currently a 4.8 billion base market

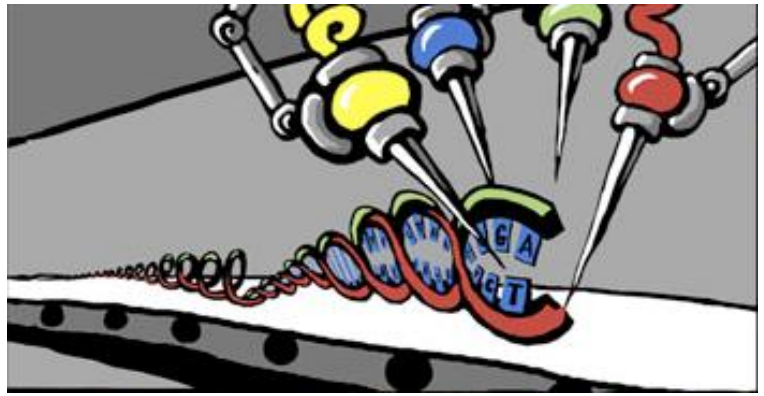
Source Rob Carlson synthesis.cc – March 2016



Polio genome = Approx $525 to synthesize??

7500bp

Genome WRITING



Human genome currently $21 billion

The Genome Project-write (GP-write) will be an open, international research project led by a multi-disciplinary group of scientific leaders who will oversee a reduction in the costs of engineering and testing large genomes in cell lines more than 1,000-fold within ten years.

GP-write will include whole genome engineering of human cell lines and other organisms of agricultural and public health significance. Thus, the Human Genome Project-write (HGP-write) will be a critical core activity within GP-write focused on synthesizing human genomes in whole or in part. It will also be explicitly limited to work in cells, and organoids derived from them only. Because of the special challenges surrounding human genomes, this activity will include an expanded examination of the

Download the GP-write White Paper

Learn How to Get Involved

Genome ‘editing’

CRISPR-CAS9, Zinc Fingers,
TALENS, Directed Mutagenesis

Robotic Genome construction

“AI - POWERED BIOTECH”

“Zymergen’s algorithms suggest making **1,000 or so changes to the microbe’s genetic material** .
Then the robots take over, injecting the suggested DNA snippets into the specimens, testing their properties, collecting data and feeding that information back into the data trove.”

- Bloomberg

Curr Opin Chem Biol. 2015 Oct;28:150-5. doi: 10.1016/j.cbpa.2015.07.009. Epub 2015 Aug 22.

The emergence of commodity-scale genetic manipulation.

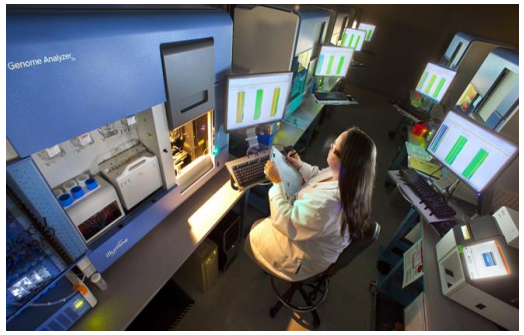
Halweg-Edwards AL[1], Grau WC[2], Winkler JD[1], Garst AD[1], Gill RT[3].

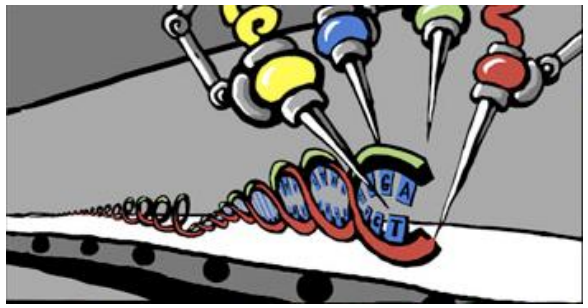
Author Information

Abstract

Since the 1970s technological advancements in the fields of synthetic biology and metabolic engineering have led to a dramatic reduction in both time and cost required for generating genomic mutations in a variety of organisms. The union of genomic editing machinery, DNA inkjet printers, and bioinformatics algorithms allows engineers to design a library of thousands of unique oligos as well as build and test these designs on a ~2 months time-scale and at a cost of roughly ~0.3 cents per base pair. The implications of these capabilities for a variety of fields are far-reaching, with potential impacts in defense, agricultural, human health, and environmental research. The explosion of synthetic biology applications over the past two decades have led many to draw parallels between biological engineering and the computer sciences. In this review, we highlight some important parallels between these fields and emphasize the importance of engineering design strategies.

PMID: 26302383 DOI: 10.1016/j.cbpa.2015.07.009





SYNTHETIC BIOLOGY INDUSTRY

- **Rapid market growth** ($10.8 billon for 2016. $38.7 billion by 2020)

- **Many deals with fortune 500** companies – food, flavour, chemicals, cosmetics, fuels, pharma, textiles.

- **Rapid expansion in venture capital** : $1.1 billion in 2016

“Over the next 20 years, synthetic genomics is going to become the standard for making anything. The chemical industry will depend on it. Hopefully, a large part of the energy industry will depend on it.”

- J Craig Venter

bp

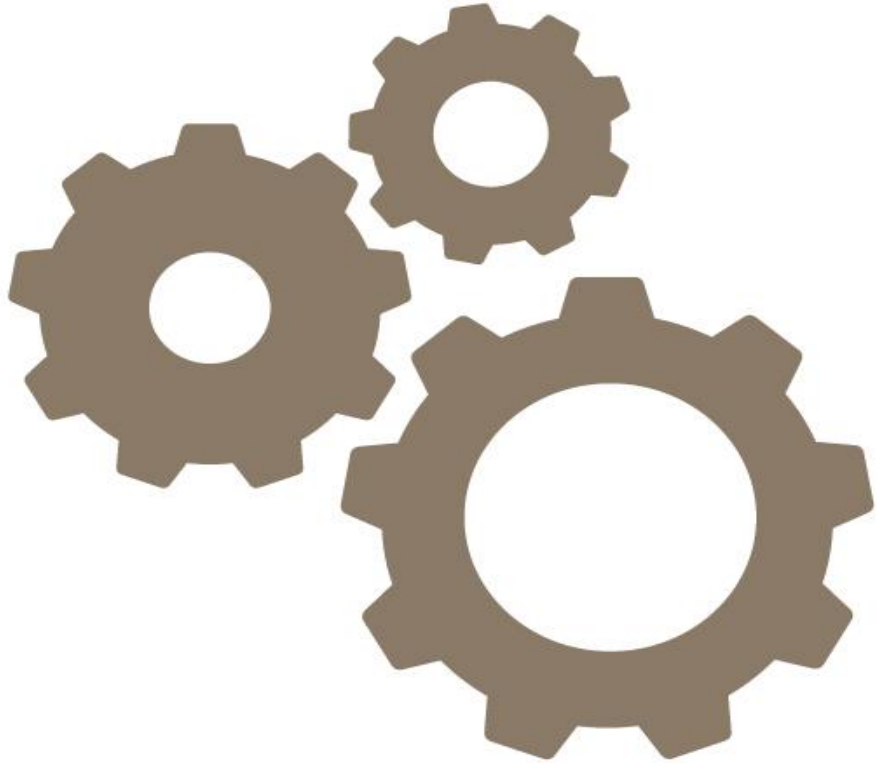
Genting Group

SYNTHETIC GENOMICS™

ExxonMobil

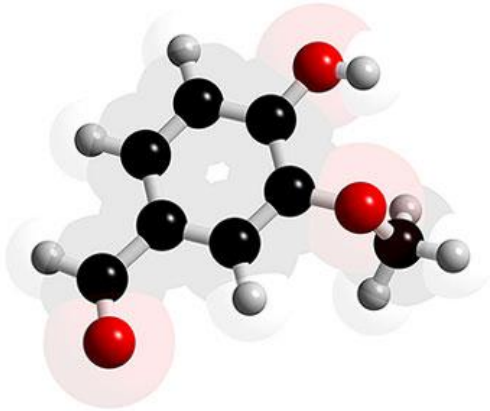
NOVARTIS

life technologies™



BIO Manufacturing

BIO
Manufacturing



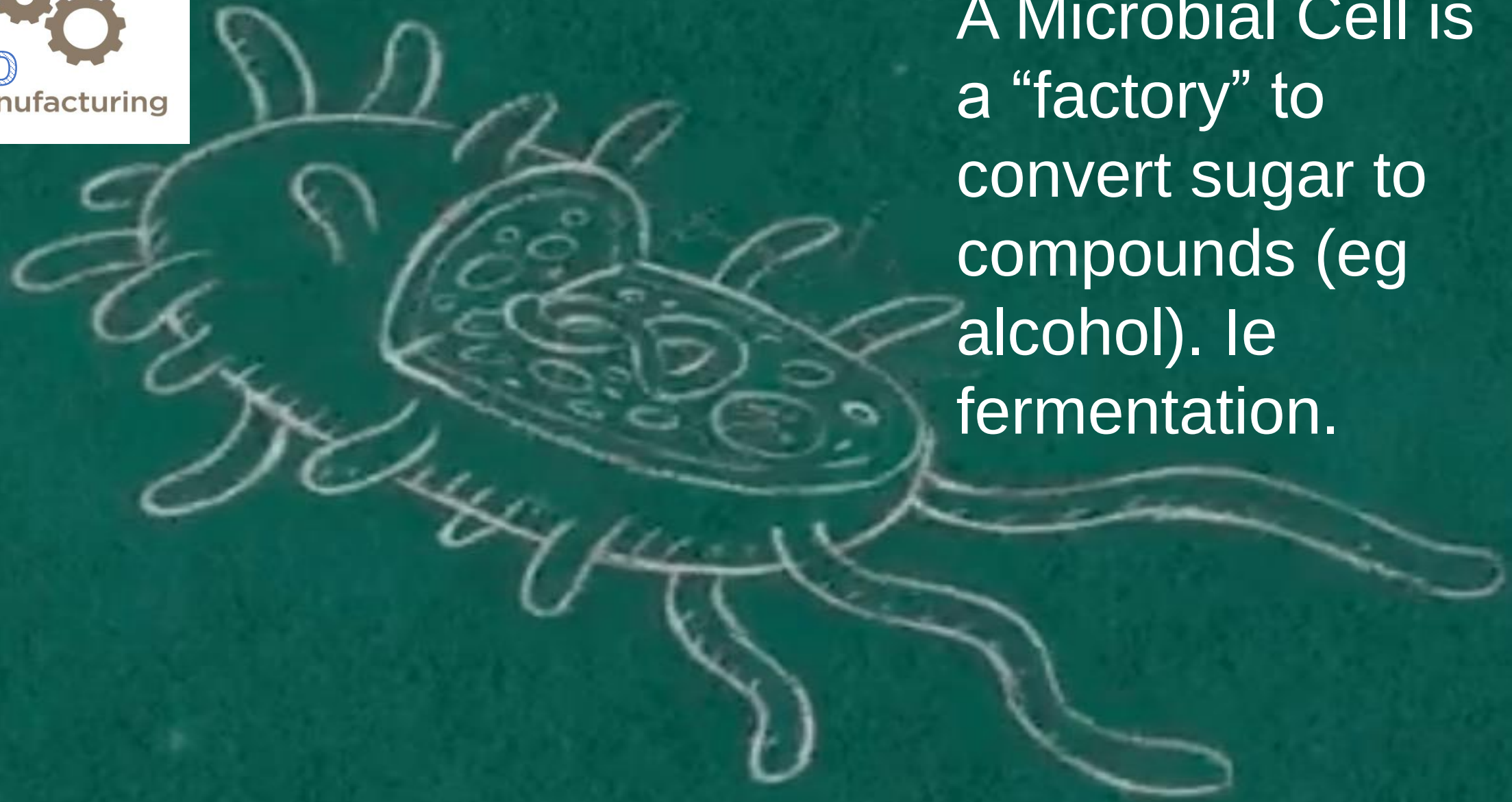
Three routes to a compound of interest: eg Vanillin

Natural Botanical Extraction
(used around 1000 years)

Artificial Chemical Synthesis
(from 1874)

Artificial Biological Synthesis
(entered market 2014)

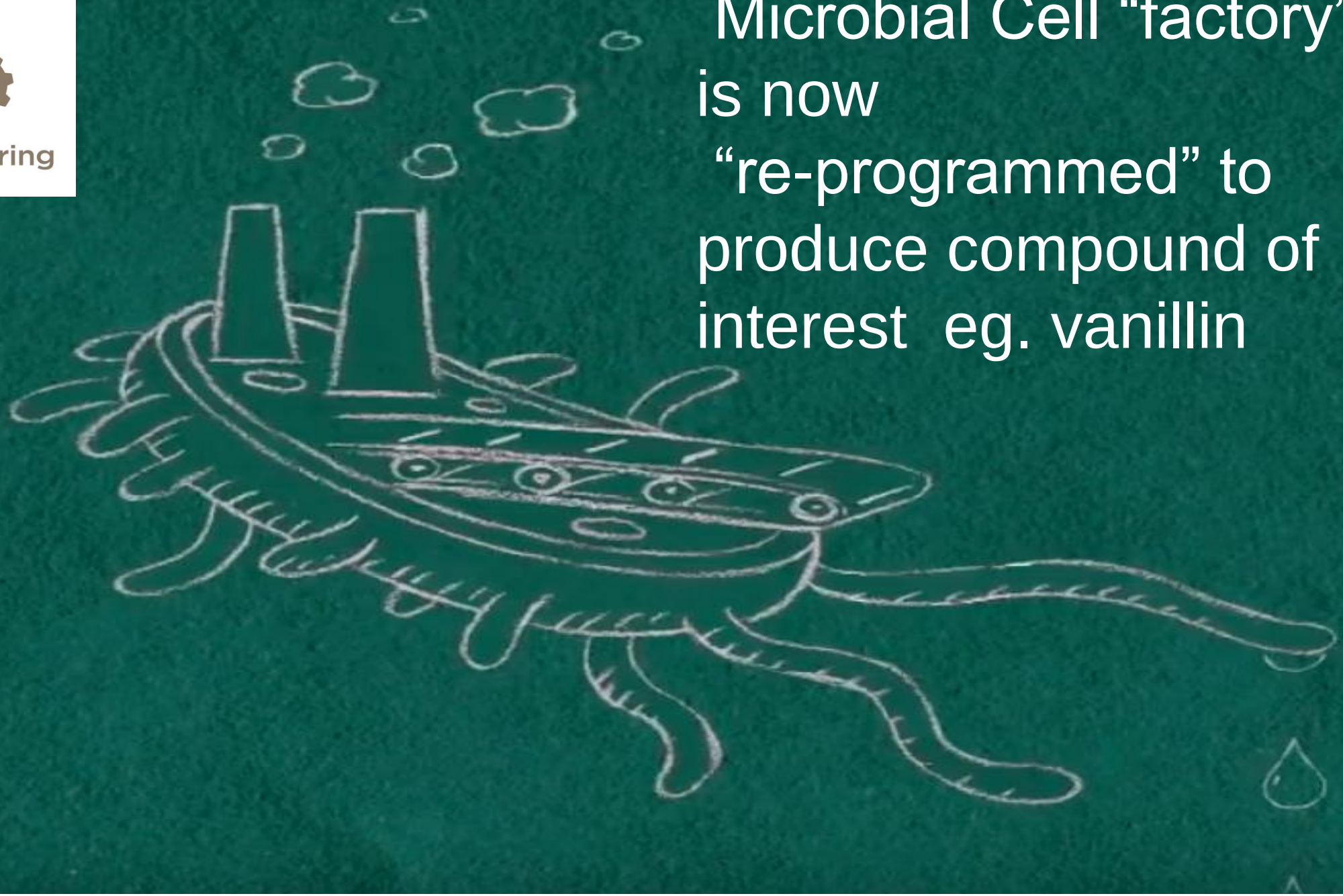
BIO Manufacturing



A Microbial Cell is a “factory” to convert sugar to compounds (eg alcohol). Ie fermentation.

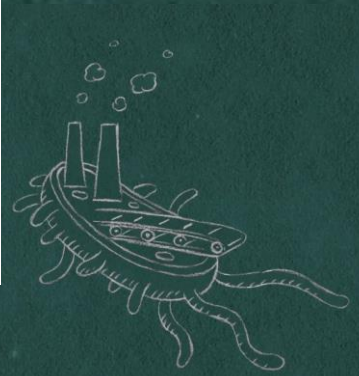
“programming” lifeforms

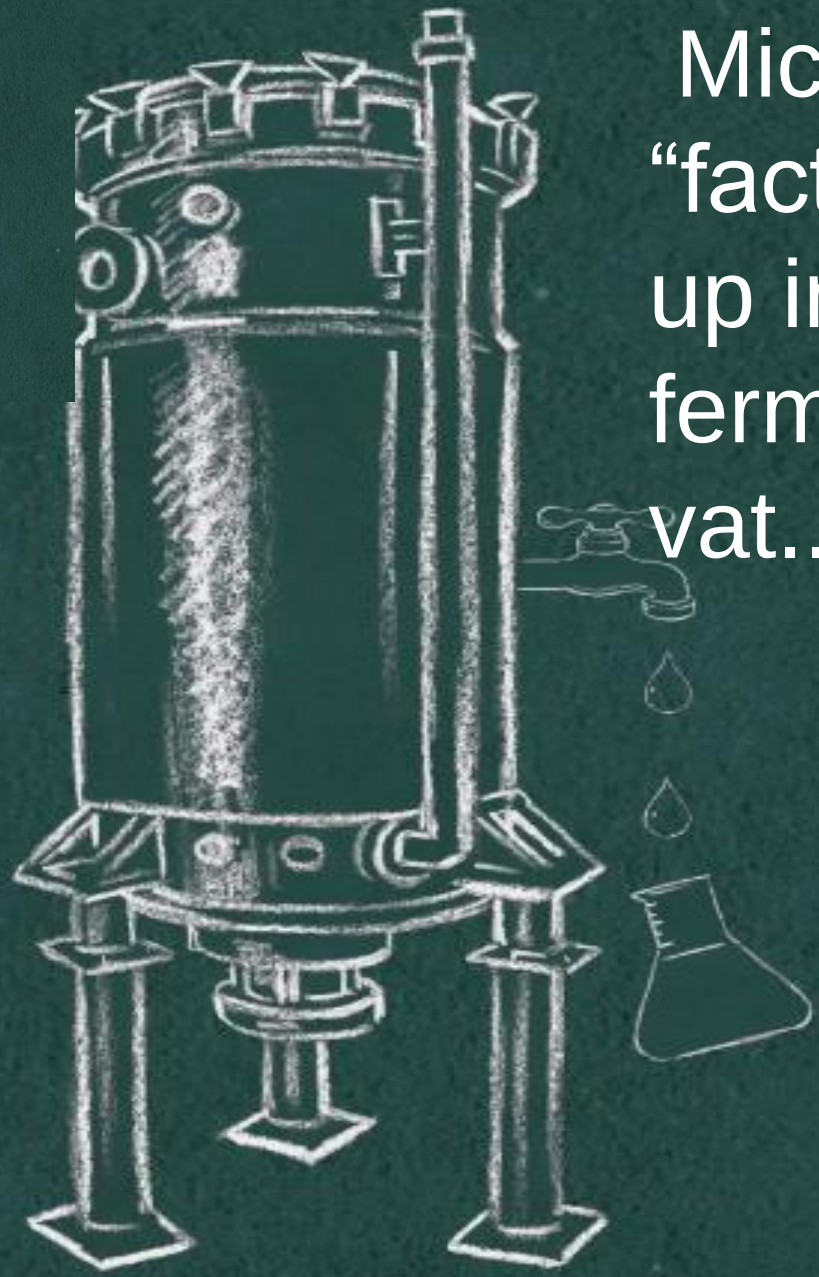
BIO Manufacturing



Microbial Cell “factory” is now “re-programmed” to produce compound of interest eg. vanillin

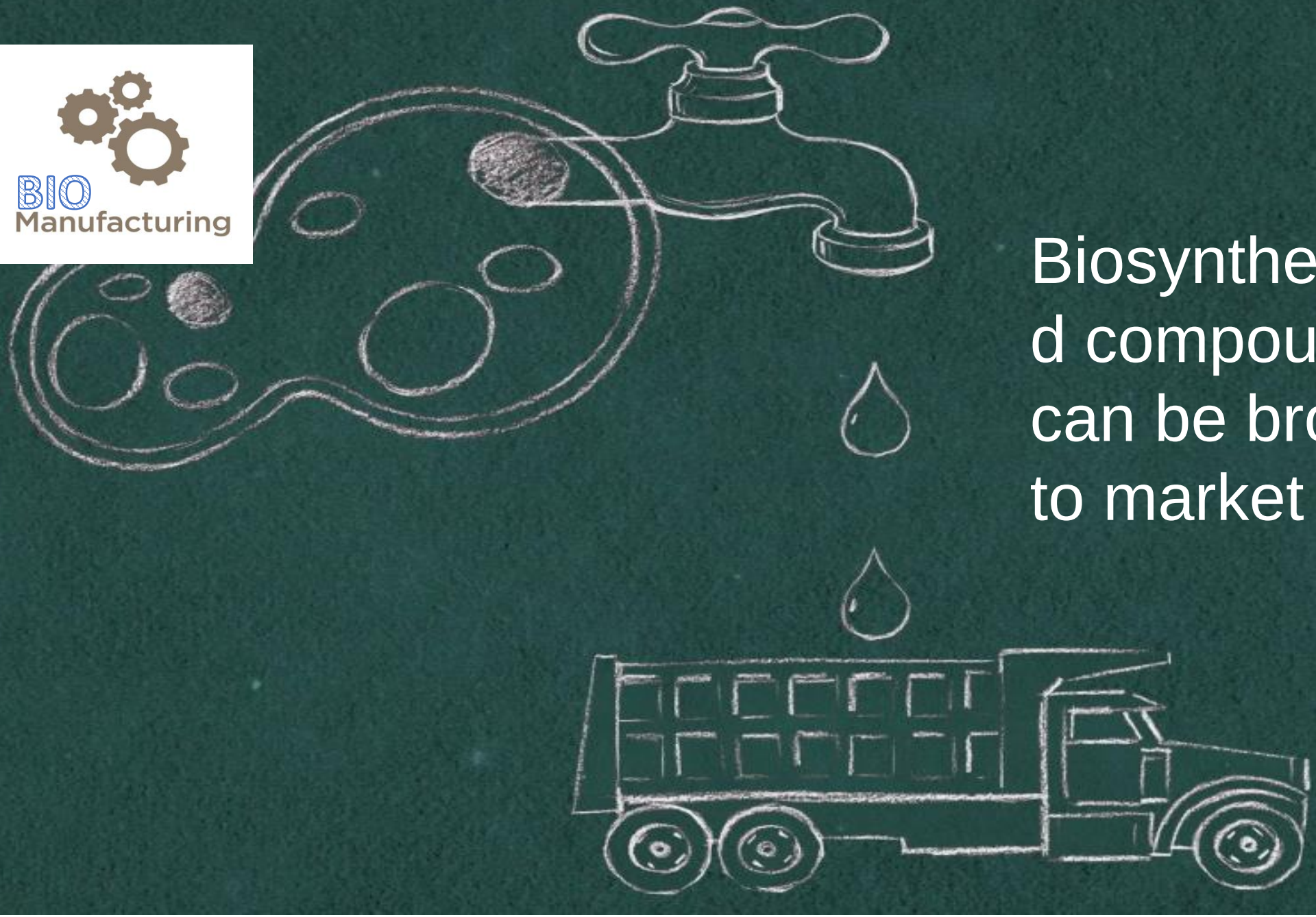
BIO Manufacturing





Microbial Cell “factory” scaled up in fermentation vat..

BIO
Manufacturing



Biosynthesisze
d compound
can be brought
to market

SYNTHETIC BIOLOGY INDUSTRY

FIRST WAVE:

Fuels And Industrial Chemicals

⇐ 2013: $2.4 billion

Of which $1.6 billion

(two thirds)

is fuels and chemicals

Shell

DUPONT

DSM

AMYRIS BIOTECHNOLOGIES

ConocoPhillips

SYNTHETIC GENOMICS

ExxonMobil

Chevron

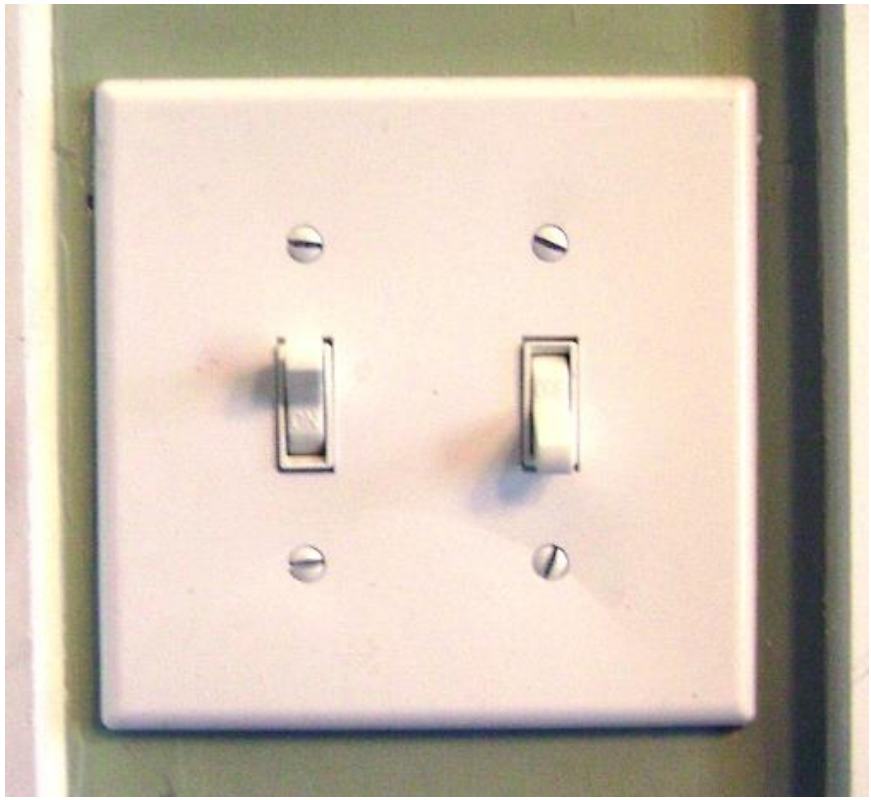
bp

TOTAL

MARATHON

DOW

< High volume, low value



Low Volume, High Value >

SYNTHETIC BIOLOGY INDUSTRY

SECOND WAVE:

Foods, Flavours, Fragrances, Soaps, Nutraceuticals, Medicines

Lead by Dr Vincent Martin (formerly Amyris inc)

$13 million CAD

75 high value plant species

PhytoMetaSyn

Papaver bracteatum Lindl.	Persian poppy	Papaveraceae	Facchini, P.
Sanguinaria canadensis L.	Bloodroot	Papaveraceae	Facchini, P.
Chelidonium majus L.	Greater celandine	Papaveraceae	Facchini, P.
Stylophorum diphyllum (Michx.) Nutt.	Celandine poppy	Papaveraceae	Facchini, P.
Eschscholzia californica Cham.	California poppy	Papaveraceae	Facchini, P.
Glaucium flavum Crantz	Yellow hornpoppy	Papaveraceae	Facchini, P.
Argemone mexicana L.	Mexican prickly poppy	Papaveraceae	Facchini, P.
Thalictrum flavum L.	Meadow-rue	Ranunculaceae	Facchini, P.
Hydrastis canadensis L.	Goldenseal	Ranunculaceae	Facchini, P.
Nigella sativa L.	Black cumin	Ranunculaceae	Facchini, P.
Xanthorhiza simplicissima Marshall	Yellowroot	Ranunculaceae	Facchini, P.
Berberis thunbergii DC.	Japanese barberry	Berberidaceae	Facchini, P.
Mahonia aquifolium (Pursh) Nutt.	Oregon-grape	Berberidaceae	Facchini, P.
Jeffersonia diphylla L. (Pers.)	Twinleaf	Berberidaceae	Facchini, P.
Menispermum canadense L.	Canadian moonseed	Menispermaceae	Facchini, P.
Corydalis cheilanthifolia Hemsl.	Fern-leaf corydalis	Papaveraceae	Facchini, P.
Nandina domestica Thunb.	Sacred bamboo	Berberidaceae	Facchini, P.
Cissampelos mucronata A. Rich.	Abuta	Menispermaceae	Facchini, P.
Tinospora cordifolia (Thunb.) Miers	Heartleaf moonseed	Menispermaceae	Facchini, P.

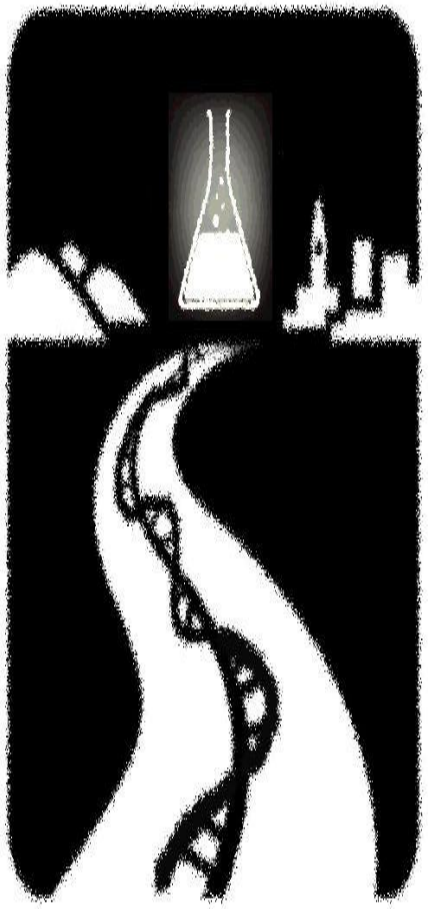
Cocculus trilobus (Thunb.) DC.	Korean moonseed	Menispermaceae	Facchini, P.
Petasites hybridus (L.) G.Gaertn., B. Mey. & Scherb.	Butterbur	Asteraceae	Ro, D.
Matricaria recutita L.	German chamomille	Asteraceae	Ro, D.
Valeriana officinalis L.	Valerian	Valerianaceae	Ro, D.
Citrus paradisi Macfad.	Grapefruit	Rutaceae	Ro, D.
Lippia dulcis (Trevir.) Moldenke	Aztec sweet herb	Verbenaceae	Ro, D.
Arnica chamissonis Less.	Chamisso arnica	Asteraceae	Ro, D.
Arnica montana L.	Leopard bane	Asteraceae	Ro, D.
Lactuca sativa L.	Lettuce	Asteraceae	Ro, D.
Xanthium strumarium L.	Rough cocklebur	Asteraceae	Ro, D.
Ligularia fischeri (Ledeb.) Turcz.	Gomchwi	Asteraceae	Ro, D.
Thapsia garganica L.	Drias plant	Apiaceae	Ro, D.
Chrysanthemum coronarium L.	Garland chrysanthemum	Asteraceae	Ro, D.
Artemisia chamaemelifolia Vill.	Chamomile-leaved artemisi	Asteraceae	Ro, D.
Artemisia absinthium L.	Absinthe wormwood	Asteraceae	Ro, D.
Artemisia maritima L.	Sea wormwood	Asteraceae	Ro, D.
Humulus lupulus L.	Common hop	Cannabaceae	Page, J.
Primula obconica Hance	Poison/German primrose	Primulaceae	Page, J.
Hypericum perforatum L.	St. John's wort	Hypericaceae	Page, J.
Cannabis sativa L.	Cannabis	Cannabaceae	Page, J.

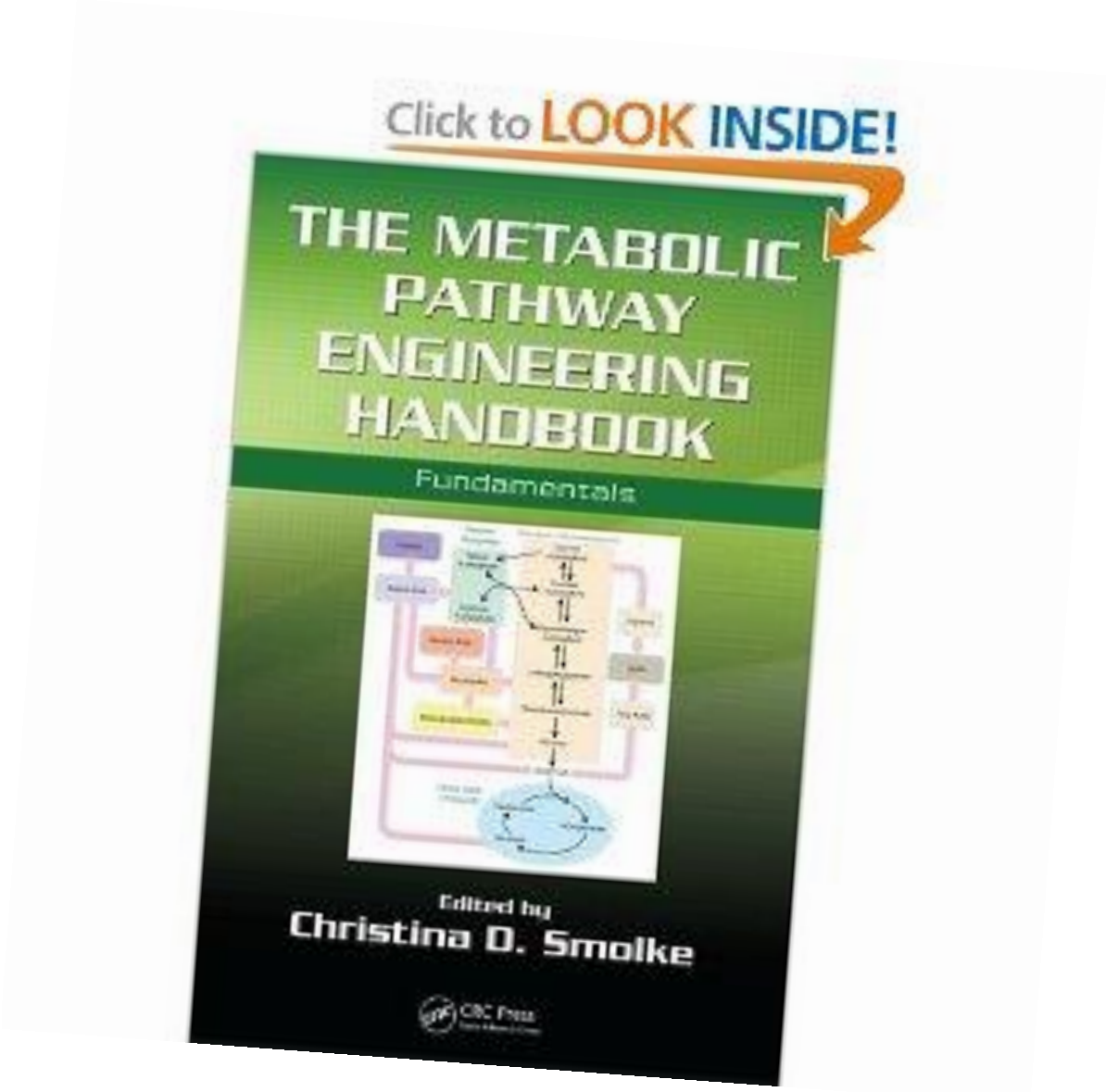
PhytoMetaSyn

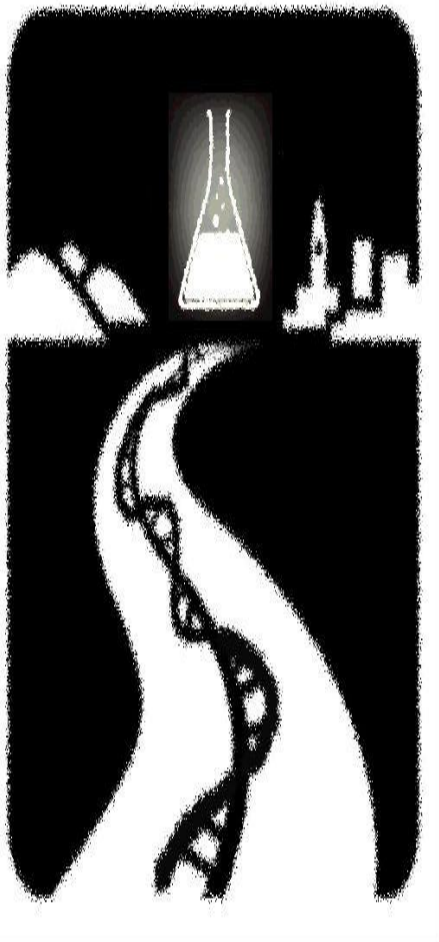
Piper methysticum G. Forst.	Kava	Piperaceae	Page, J.
Helichrysum petiolare Hilliard & B.L. Burtt	Licorice-plant	Asteraceae	Page, J.
Vancouveria hexandra (Hook) C. Morren & Decne.	White inside-out flower	Berberidaceae	Page, J.
Rheum rhabarbarum L.	Garden rhubarb	Polygonaceae	Page, J.
Hydrangea macrophylla (Thunb.) Ser.	Bigleaf hydrangea	Hydrangeaceae	Page, J.
Pelargonium x *hortorum* L.H. Bailey	Common geranium	Geraniaceae	Page, J.
Prunella vulgaris L.	Common selfheal	Lamiaceae	Covello, P.
Platanus occidentalis L.	American sycamore	Platanaceae	Covello, P.
Centella asiatica (L.) Urban	Indian pennywort, gotu kola	Apiaceae	Covello, P.
Saponaria vaccaria L.	Prairie carnation, cowcockle	Caryophyllaceae	Covello, P.
Dianthus superbus L.	Large pink	Caryophyllaceae	Covello, P.
Silene vulgaris (Moench) Garcke	Bladder campion	Caryophyllaceae	Covello, P.
Acacia victoriae Benth	Gundabluie	Fabaceae	Covello, P.
Diospyros kaki L. f.	Japanese persimmon	Ebenaceae	Covello, P.
Swietenia mahagoni (L.) Jacq.	West Indian mahogany	Meliaceae	Covello, P.
Cedrela sinensis (*Toona sinensis*) (A. Juss.) M. Roem.	Chinese mahogany	Meliaceae	Covello, P.

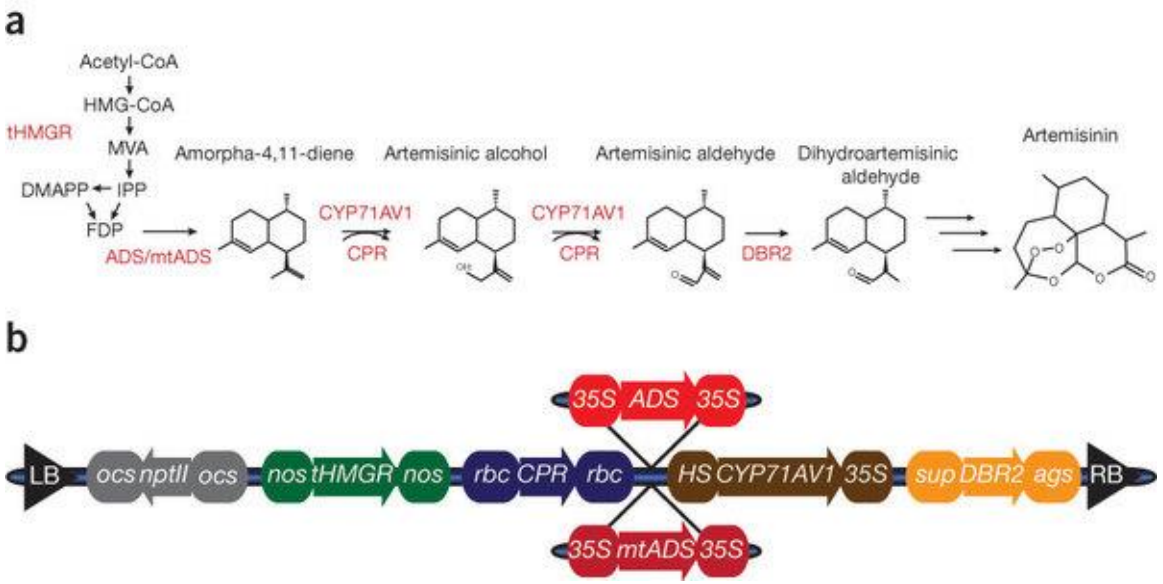
Vinca minor L.	Lesser periwinkle, myrtle	Apocyanaceae	DeLuca, V.
Rauwolfia serpentina (L.) Benth. ex Kurz	Indian snakeroot	Apocyanaceae	DeLuca, V.
Camptotheca acuminata Decne.	Happy tree, tree of life	Nyssaceae	DeLuca, V.
Lonicera japonica Thunb.	Japanese honeysuckle	Caprifoliaceae	DeLuca, V.
Cinchona ledgeriana (Howard) Bern.	Jesuit's bark	Rubiaceae	DeLuca, V.
Catharanthus ovalis Markgr.	Catharanthus ovalis	Apocyanaceae	DeLuca, V.
Catharanthus longifolius (Pichon) Pichon	Catharanthus longifolius	Apocyanaceae	DeLuca, V.
Tabernaemontana elegans Stapf	Milkwood, toad tree	Apocyanaceae	DeLuca, V.
Amsonia hubrichtii Woodson	Hubricht's bluestar	Apocyanaceae	DeLuca, V.
Catharanthus roseus (L.) G. Don	Rosy periwinkle	Apocyanaceae	DeLuca, V.
Abies balsamea L. (Mill.)	Balsam fir	Pinaceae	Bohlmann, J.
Grindelia integrifolia DC.	Entire-leaved gumwood	Asteraceae	Bohlmann, J.
Pseudolarix amabilis (J. Nelson) Rehder	Golden larch	Pinaceae	Bohlmann, J.
Tripterygium wilfordii Hook. f.	Thunder god vine	Celastraceae	Bohlmann, J.

Metabolic pathway engineering



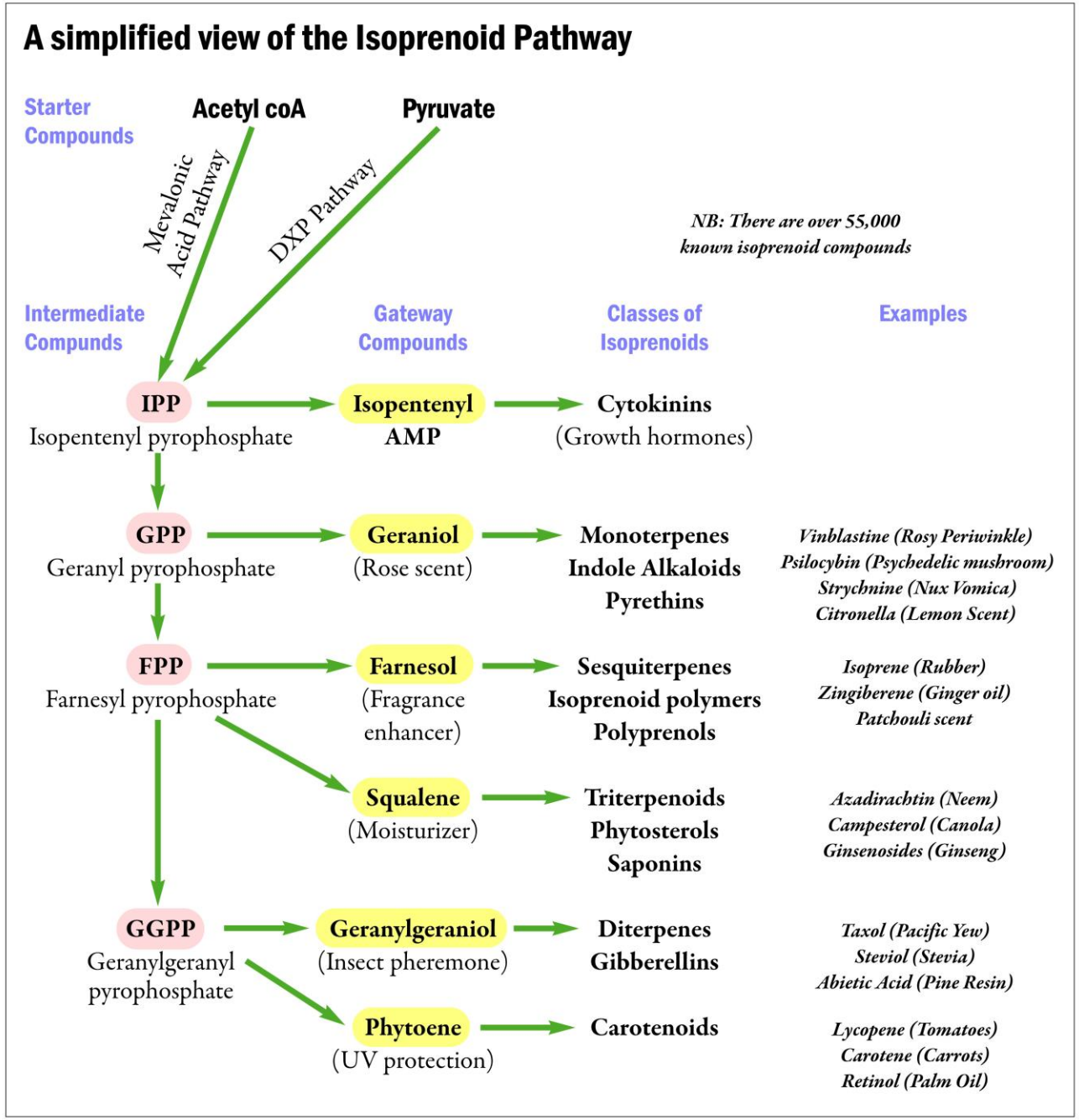






AMYRIS

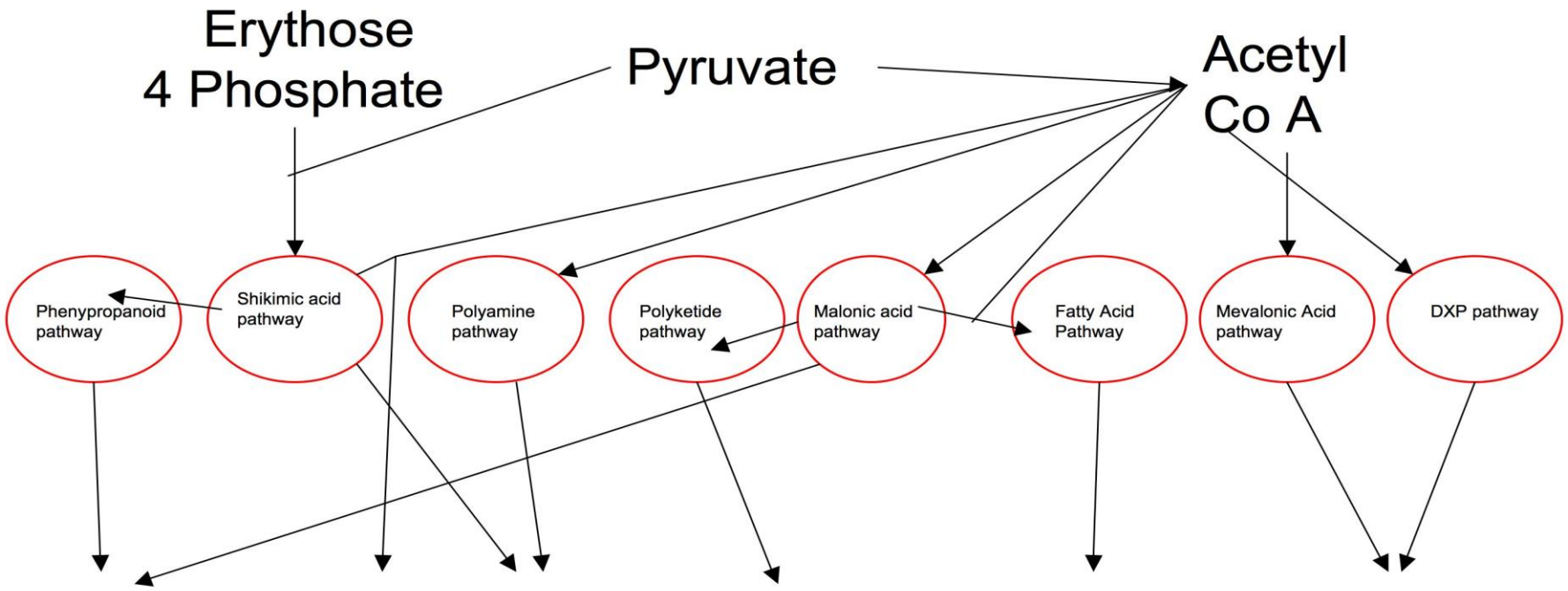
SANOFI



Isoprenoids

=

class of
Up to 75,000
compounds.



Phenols
tannins
flavonoids
polyphenols
stilbenes
Cinnamates
Coumarins

Hemiterpenes
monoterpenes
sesquiterpenes
diterpenes
tetraterpenes
pyrethins
indole alkaloids
sterols

Over 200,000 natural compounds

Evolva – a yeast "metro" for valuable products

evolva

Ambergris

Pyrethrin

Caffeine

Opiates

Cocoa

Sandalwood

Stevia

Saffron

Musk

Frankincense

Caviar

Mint

Capsiate

Taxol

Vanilla

Dopamine

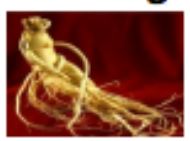
Resveratrol

Turmeric

Carmine

Breast Milk

Ginseng



Truffles

There is potential for biosynthetic routes to completely replace any natural sources”

-Kalib Kersh

Industry Analyst, Lux Research

AMYRIS

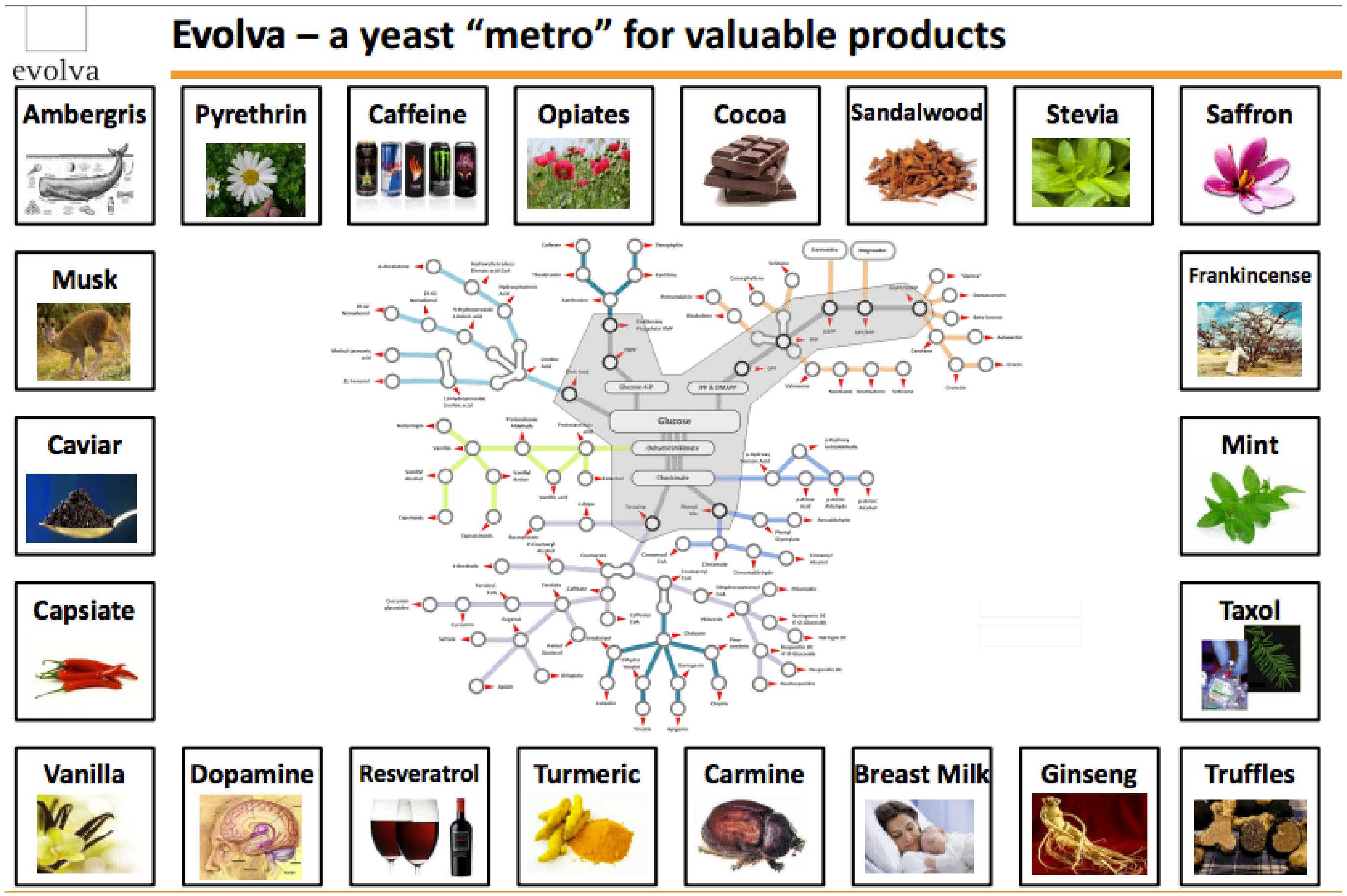
“Through the **Pathways Program,** partners can, with a small initial investment,

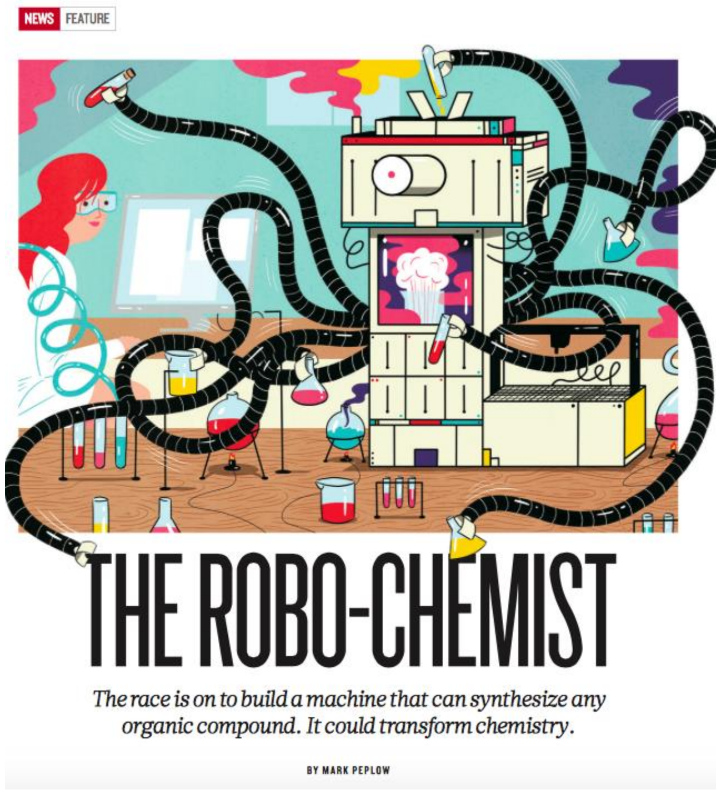
sponsor and secure a molecule

they are interested in having Amyris produce using the next-generation tools and technologies being developed through the company’s recently announced technology investment agreement with the Defense Advanced Research Projects Agency (DARPA). Amyris expects the powerful combination of its existing core technology and bioengineering advancements enabled by its project with DARPA will significantly reduce the time and cost of bringing new molecules to market using industrial biotechnology. The Pathways Program allows partners to access these latest developments and

explore bio-synthetic production opportunities

with minimal risk and commitment. ”

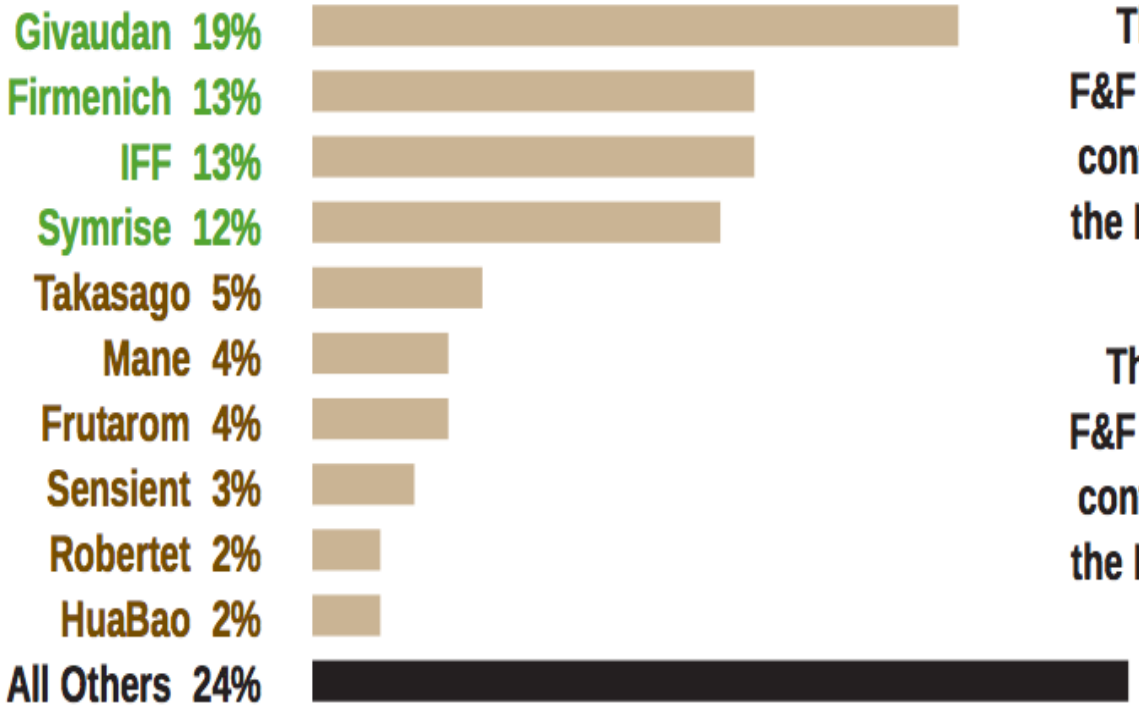




"Dial a molecule"
"synthesis machine"

"Print on demand for synthetic botanicals"

Flavor & Fragrance Industry: Market Share by Company, 2015



The Top 4 F&F companies control 57% of the F&F market

The Top 10 F&F companies control 80% of the F&F market

Firmenich

IFF International Flavors & Fragrances Inc.

DSM

Unilever

Six of the top 10 companies have entered R&D agreements with synthetic biology firms or have their own synthetic biology R&D activities.

Givaudan

BASF
The Chemical Company

Health & Science

Report: Habitable planets may be common

Is Detroit poised for a white mayor?

Funny. Profane. And a preacher.

Companies rush to build 'bio-factories' for medicines, flavorings and fuels

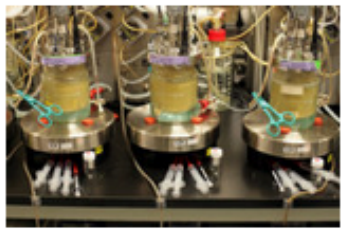
View Photo Gallery — Bio-factories bring new drugs, flavorings and fuels: Scientists

What's That Smell? Exotic Scents Made From Re-engineered Yeast

By ANDREW POLLACK
Published: October 20, 2013 | 53 Comments

EMERYVILLE, Calif. — Vanilla, saffron, patchouli. For centuries, spices and flavorings like these have come from exotic plants growing in remote places like the jungles of Mexico or the terraced hillsides of Madagascar. Some were highly prized along ancient trading routes like the Silk Road.

Enlarge This Image



Jim Wilson/The New York Times

Fermenters at Amyris, a company in Emeryville, Calif., that modifies yeast to make products that include a malaria drug

Now a powerful form of genetic engineering could revolutionize the production of some of the most sought-after flavors and fragrances. Rather than being extracted from plants, they are being made by genetically modified yeast or other micro-organisms cultured in huge industrial vats.

Flavours and Fragrance (F&F) Market:

- 26.5 Billion dollar market in 2016
- Expected to grow to over $35 billion by 2019
- Includes essential oil exports valued at US$3.6 billion in 2012.
- The F&F industry currently sources 200 to 250 different botanical crops grown on an estimated 250,000 hectares worldwide.
- Around 95% of these crops are grown by small-scale farmers and agricultural workers, mostly in the global South.
- An estimated 20 million small-scale farmers and agricultural workers depend on botanical crops sourced for natural flavors and fragrances. (low estimate and does not include common flavors such as cocoa or coffee.)

Why is the F&F industry going all-in on Syn Bio replacements?

1. Reliability/control over supply

2. “Natural” claim

3. Price

Advantages to ingredient manufacturers:
1) Control over Supply .

Advantages to ingredient manufacturers:

1) Control over Supply .

Advantages to ingredient manufacturers:
1) Control over Supply .

"We can dislocate the production of that oil from a tropical climate to the middle of Iowa in winter … It is truly revolutionary that we can take what is a normal crop cycle and compress that into three days"

- Mark Brooks. Senior VP
Solazyme/TerraVia

"**Step aside, Cocoa Farm, Synthetic Biology is on its way!"**

– Maxx Chatsko Synbiobeta

Advantages to ingredient manufacturers:
2) ”Natural” claims.

IFF International Flavors & Fragrances Inc.

evolva

On market since 2014 – in “natural’ flavours.

evolva

IFF International Flavors & Fragrances Inc.

IFF/Evolva make ‘natural’ claims because

FERMENTATION

Despite highly unnatural production method

evolva

IFF International Flavors & Fragrances Inc.

"The need for Natural is the key driver"

- Ahmet Baydar, IFF director of research and development in New York Times

evolva

IFF International Flavors & Fragrances Inc.

"From my point of view its fundamentally as natural as beer or bread…
I'm comfortable that if beer is natural then this is natural"

-Neil Goldsmith, CEO Evolva

ECOVER
POWERED BY NATURE

method.
for the love of clean™

solazyme

Unilever

BUSINESS

To Wash Hands of Palm Oil Unilever Embraces Algae

Consumer-Goods Maker Invests in California's Solazyme to Avoid Environmental Concerns Associated with Palm Oil

By PAUL SONNE

Updated Sept. 7, 2010 12:01 a.m. ET

LONDON—As food and consumer-goods companies face problems obtaining the key ingredient palm oil without damaging the environment, Unilever is betting on a promising low-life alternative: algae.

London-based Unilever, which relies on palm oil to make Dove soap, Vaseline lotion

Synthetic Biology is not Natural

Keep extreme genetic engineering out of "natural" products

Sign the Petition: Synthetic Biology is Not "Natural"

Dear Method and Ecover,

As consumers, we trust that when a company calls itself natural and sustainable, its products won't contain ingredients produced via genetic engineering or synthetic biology. Method's parent company, Ecover, has just announced that it will be introducing a new ingredient, synthetic biology-derived algal oil, into its products. Method has indicated that it will follow the same route. This oil will be produced with new, virtually unregulated, unassessed experimental extreme genetic techniques.

The synthetic biology-derived oil that Method and Ecover are supporting is far from 'natural'. It is from highly novel bioengineered algae made in labs using synthetic DNA. Like many of the products of genetic engineering, it won't be labeled or subject to

English

Additional reading

23 Organizations: Open Letter to Ecover / Method on Ingredients Derived from Synthetically Modified Organisms

New York Times: Companies Quietly Apply

AMYRIS

Brand: Neossance, Biossance

- 30 million people employed by olive sector
- Market Value $94 million USD
- Syn Bio “Sugar Squalane” more than 30% cheaper than Olive-derived
- In 300 products+
- Marketed as Sustainable: “plant-based”, Ecocert –certified, EWG verified and ‘The Natural Seal’ and even false GMO-Free claim!

NATURAL PRODUCTS ASSOCIATION
CERTIFIED ®

DuPont Tate & Lyle
Zemea™
renewably sourced™ propanediol

Country life vitamins llc

- Brand: Eversweet (Cargill/DSM)
- Tens of thousands of farmers (Paraguay, China, Kenya, USA)
- Indigenous traditional ingredient from Paraguay
- $600 million USD market by 2020
- **Strongly opposed by Stevia industry because of impact on “natural” image** and paraguayan indigenous groups.
- Advantage: Reb M and D not Reb A

Synthetic Biology, Biodiversity & Farmers

etc GROUP
monitoring power
tracking technology
strengthening diversity
www.etcgroup.org

Case studies exploring the impact of synthetic biology on natural products, livelihoods and sustainable use of biodiversity

Natural Products Map

Exploring the impact of synthetic biology on natural products, livelihoods and sustainable use of biodiversity

A fundamental shift is underway in how food, flavor, cosmetic, and fragrance ingredients are being produced for global markets. The new game in town is synthetic biology, or GMOs 2.0—companies are now able to create yeasts, algae and other microbes that secrete artificial compounds that taste or smell like familiar substances but don't actually come from the natural source.

Several products on the market already contain synthetic biology ingredients—check out this shopper's guide on synthetic biology to learn more about how to avoid syn bio in your food and cosmetics.

Sneaking syn bio in to products as "natural" is bad news for consumers, and it is also bad news for the farmers, growers, pickers and harvesters who provide the real natural products in our food, cosmetics, soaps, and more. Companies use the excuse of sustainability and local food security to justify the transition from field production to vat production—but many of these natural products grow in difficult environments that are not suited to food crops, so offer very high-value for farmers who may not have other good sources of income. Sourcing raw fragrance and flavor materials from a vat instead of from millions of diverse farmers only offers companies simpler supply chains and increases corporate control over the product process.

In these case studies, ETC Group outlines how 13 specific products are being bio-synthetically created and how traditional livelihoods may be adversely affected as these syn bio substitutes enter the market. This map is for civil society organizations, researchers, and policymakers that want to understand how syn bio flavors and fragrances might affect their work at the country level. You can also download the full report "Synthetic Biology, Biodiversity and Farmers".

Natural Products Map Home

- Intro to syn bio flavors and fragrances
- Agarwood Oil
- Ambergris and Clary Sage Oil
- Artemisia - Artemisinin
- Ginseng
- Patchouli Oil
- Rose Oil
- Saffron
- Sandalwood
- Shea, Cocoa Butter and Other Cocoa Butter Equivalents (CBEs)
- Squalane (Olive)
- Stevia
- Vanilla
- Vetiver

database.synbiowatch.org

SynBioWatch GMO 2.0 Ingredients Database

A SEARCHABLE GUIDE TO INGREDIENTS PRODUCED USING NEXT GENERATION GENETIC ENGINEERING.

Synthetic Ingredients

Displaying 1 - 4 of 4

R

RESVERATROL by Evolva
Company: Evolva
Current Status: ON THE MARKET
Category: Supplement

RETINOID (Carotenoids)
Company: Industry-Academic cooperation Foundation Gyeonsand National University
Current Status: UNDER DEVELOPMENT
Category: Supplement, Food, Pigment

ROSE SCENT by Celbius
Company: Celbius
Current Status: COMING TO MARKET
Category: Flavour and Fragrances, Food, Cosmetics

ROSE SCENT by Ginkgo
Company: Ginkgo Bioworks (US)
Current Status: ON THE MARKET

Search Database

Search everything

Ingredient Name

Company

Current Status

- Any -

Category

- Any -

Search ingredients

RESVERATROL by Evolva

Brand Names: Veri-te™ or EveResveratrol
Current Status: ON THE MARKET
Company: Evolva
Distributors:
Evolvas Veri-te™ is distributed by Natural Functional Ingredients (http://www.natural-ingredients.fr/) Breko (http://www.breko.de/) Lithos Ingredients (http://www.lithosingredients.nl/index.htm) Nortrade Pharma (poland@nortradepharma.com) Savanna
References
http://veriteresveratrol.com/
https://trademarks.justia.com/867/55/eve-86755221.html
Compound: Resveratrol
Category: Supplement

SynBioWatch GMO 2.0 Ingredients Database

A SEARCHABLE GUIDE TO INGREDIENTS PRODUCED USING NEXT GENERATION GENETIC ENGINEERING.

Search for chili peppers

Search Fields

Enter your keywords: Search

chili peppers

Search help

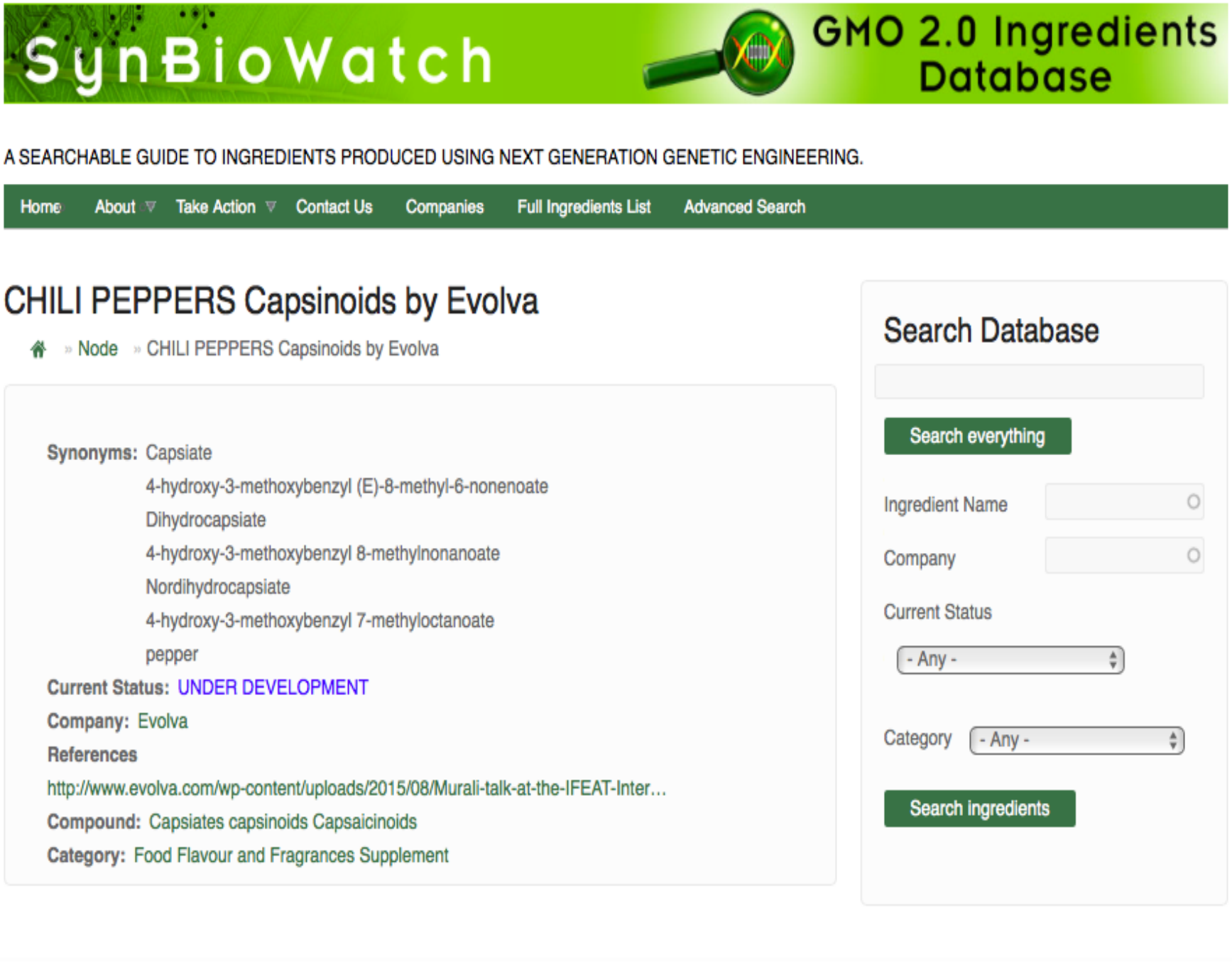
Search results

CHILI PEPPERS Capsinoids by Evolva

CHILI PEPPERS Capsinoids by Evolva Synonyms ...

CHILI PEPPERs Capsinoids by Conagen

CHILI PEPPERs Capsinoids by Conagen Synonyms ...



Chile pepper production for fresh market and processing in 2014 was 463 million pounds on 19,100 acres, valued at $216.1 million

Small Chilies Bring Big Impact to Rural Uganda

Posted by **Elizabeth Teague** | Jul 31, 2014 10:25:27 AM

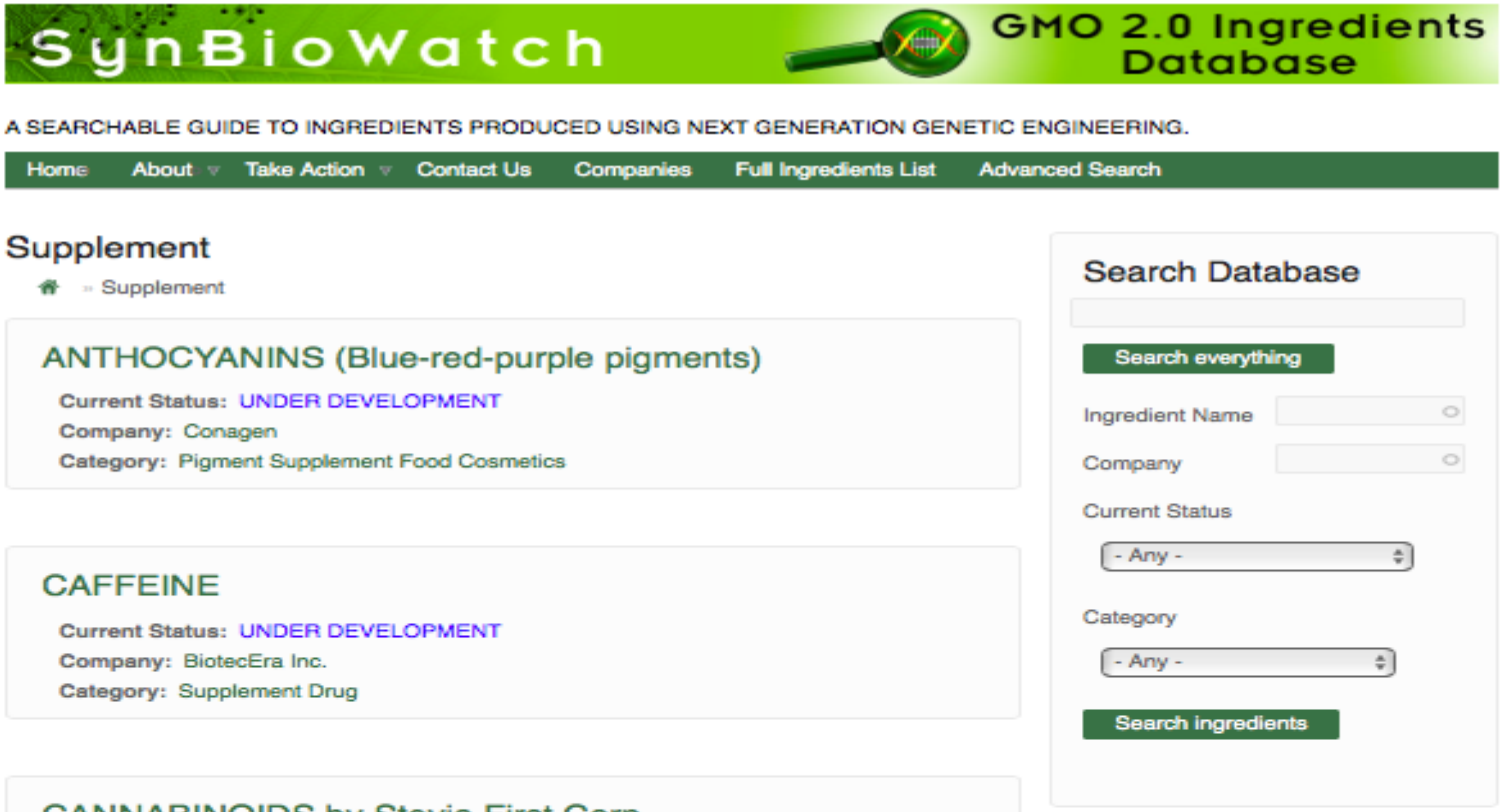
In 2011, Root Capital began conducting studies of a subset of our clients to evaluate whether and how our client businesses support farmer livelihoods and understand Root Capital's impacts on clients' businesses. The results from our case study with Sunshine Agro Products Limited are highlighted below. For more case studies and general information on our approach to measuring impact, see our ***Impact page****.*

Sometimes, the smallest things can change a life. In rural Uganda, the lives of more than 900 farmers have been changed by something very small, very spicy, and very valuable: the *Capsicum frutescens*, or the African bird's eye pepper.

in a country with a gross national income (GNI) of $549 per capita, Sunshine has grown from 15 to 924 chili farmers – both men and women for whom chili and spice farming accounts for an average of an additional $28 per household member or **$140 per year/per family**

Thirty percent of Sunshine's suppliers are women, and on average, each woman supports a family of eight on a half-acre of chili peppers. "Chili has completely improved my life," said one female farmer. "I was never able to save any money or even buy anything personal. But now I can visit my children at school any time."

The supplement aisle at Wholefoods Santa Fe

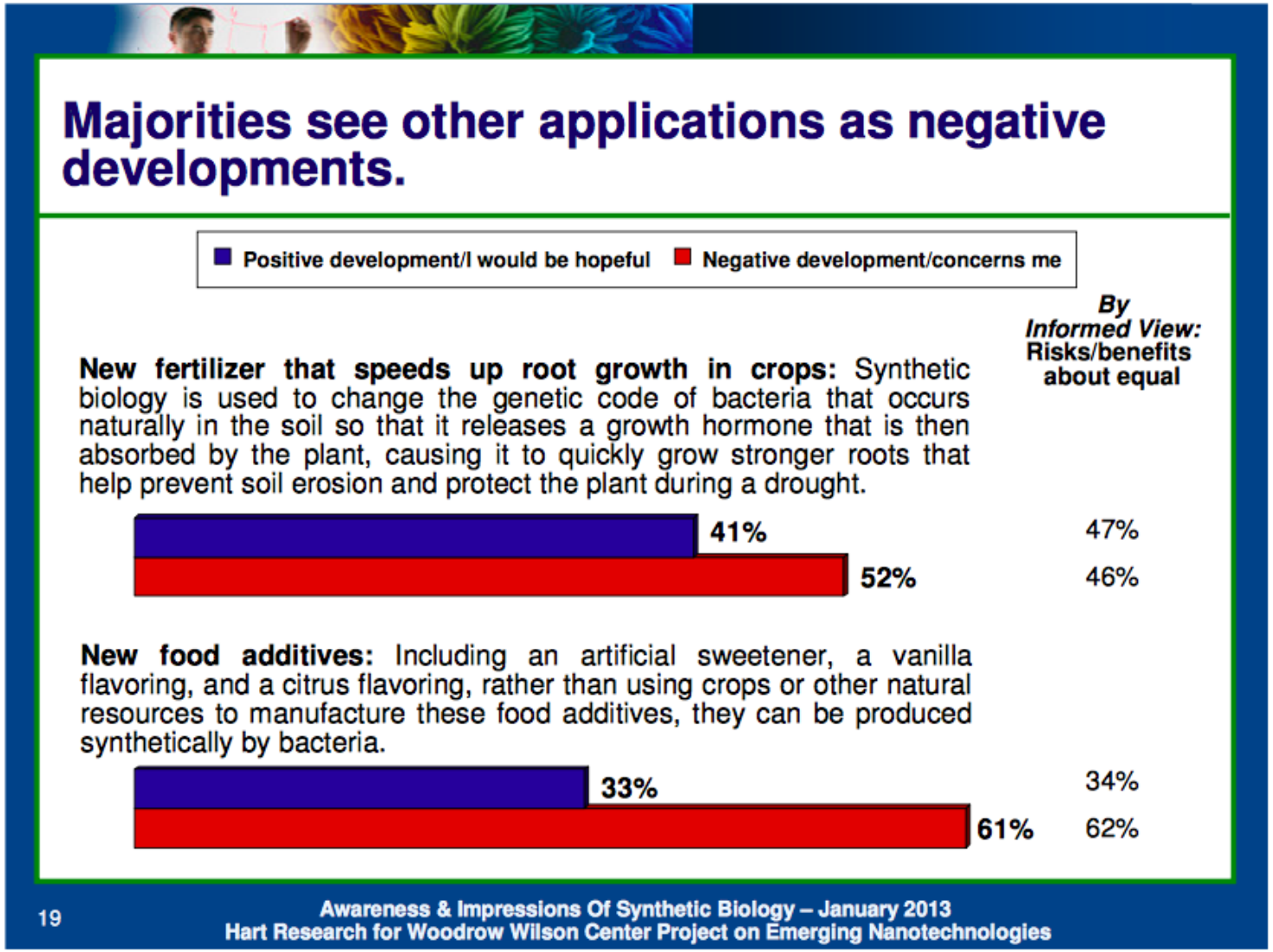


156 entries relevant to supplements

Q: **Will Natural Product Consumers accept Syn Bio ingredients?**
A: Very unlikely.

Consumers want:

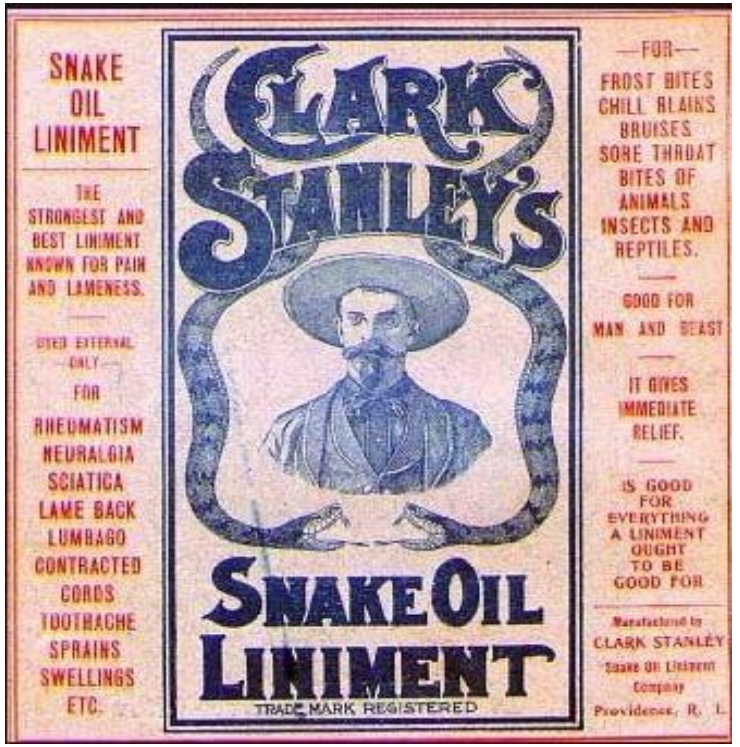
1. **TRANSPARENCY**
2. **AUTHENTICITY**
3. **CLARITY**



Authenticity?

101 years of fake ‘naturals’?

May 20th 1916 – FDA raids Clark Stanley - the “rattlesnake king”



SynBioWatch

GMO 2.0 Ingredients Database

A SEARCHABLE GUIDE TO INGREDIENTS PRODUCED USING NEXT GENERATION GENETIC ENGINEERING.

Home | About | Take Action | Contact Us | Companies | Full Ingredients List | Advanced Search

Search for omega 3

Search Fields

Enter your keywords: omega 3 Search

Search help

Search results

ALGAE OIL (Omega 3 for Animal Feed)

ALGAE OIL (**Omega 3** for Animal Feed) Current Status ... Uses and Applications **Omega 3** for A

OMEGA 3 DHA ALGAE OIL by Martek/DSM

OMEGA 3 DHA ALGAE OIL by Martek/DSM Synonyms Fatty Acids **Omega 3** DHA Algae oil ...

OMEGA 3 FATTY ACIDS by CHAIN Biotech

OMEGA 3 FATTY ACIDS by CHAIN Biotech Synonyms **OMEGA-3** Fatty Acids DHA EPA ...

ANIMAL FEED by Sapphire Energy

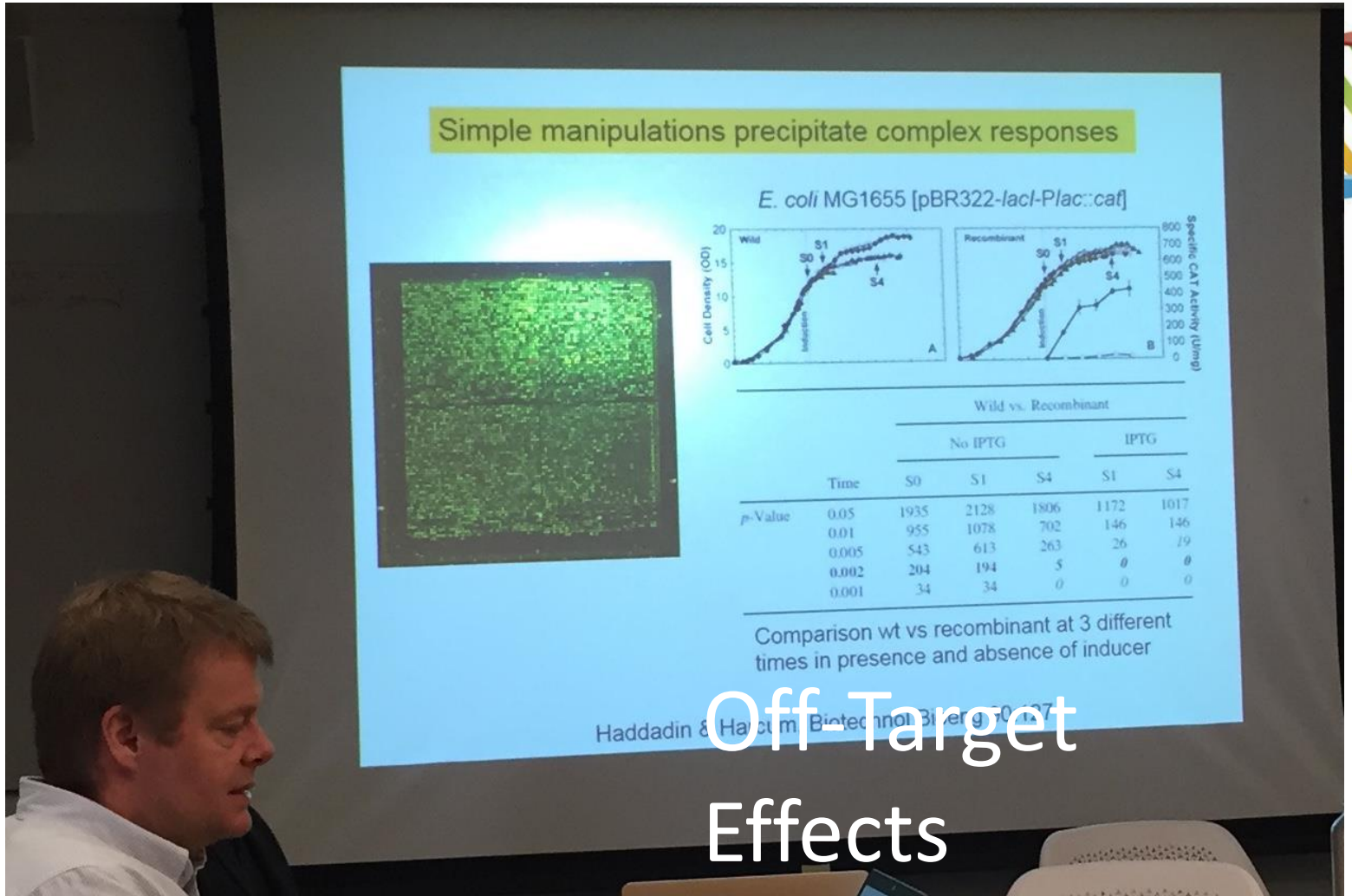
... Compound **Omega 3** and Animal Feed ...

OMEGA-3 DHA YEAST OIL

Authenticity?

Q: is it safe to consume with ingredients produced through syn bio?
A: Unclear.

Problem of off-target effects, altered metabolism, unexpected contaminants.. Red Flags: artemisinin, tryptophan, Soylent.



- In 1989 in the US L-tryptophan, produced using GM bacteria, was found to be toxic, killing 37 people and disabling over 1500 - eosinophilia myalgia syndrome (EMS).
- Traced back to a single source, Showa Denko had introduced a new genetically engineered bacterium, called Strain V, in December 1988, a few months before the main epidemic hit.
- There was debate whether contaminant was genetic engineering or change in carbon filtration process. Blaming a failure in filtration does not answer the question of how the toxin got into the product. This was a novel toxin that was not found in other companies' L-tryptophan products.
- , Dr Michael Osterholm (epidemiologist at the Minnesota Department of Health_: the new bacterial strain "was cranked up to make more L-tryptophan and something went wrong. This obviously leads to that whole debate about genetic engineering."[7]

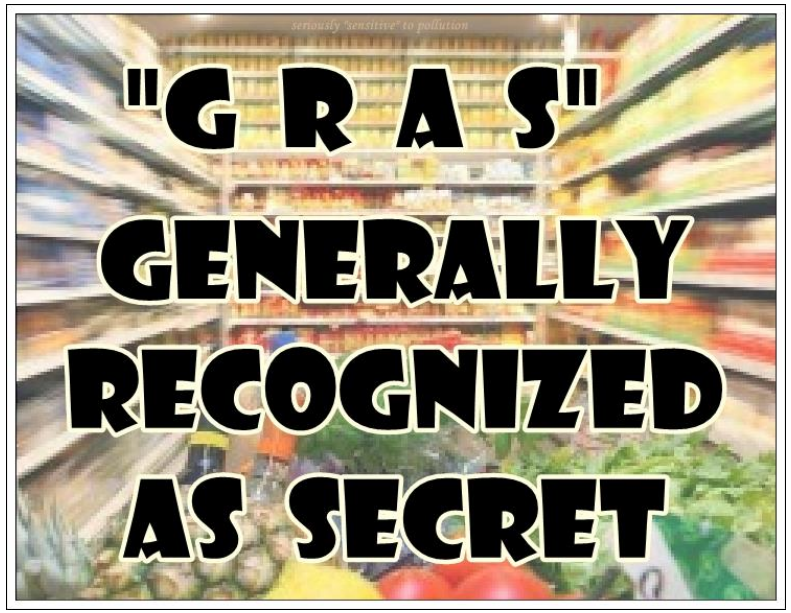
WHO recommendations (draft) on ART as Starting Material

	2010	2011	2012
ART	95-102	Same	Same
Artemisitene	0.08	**0.15**	**0.2**
9-epiART	1	same	same
Total impurity	5	**3**	**3**

Artemisitene levels going up, up and up

Q: Are Syn Bio ingredients regulated?

A: Not really...

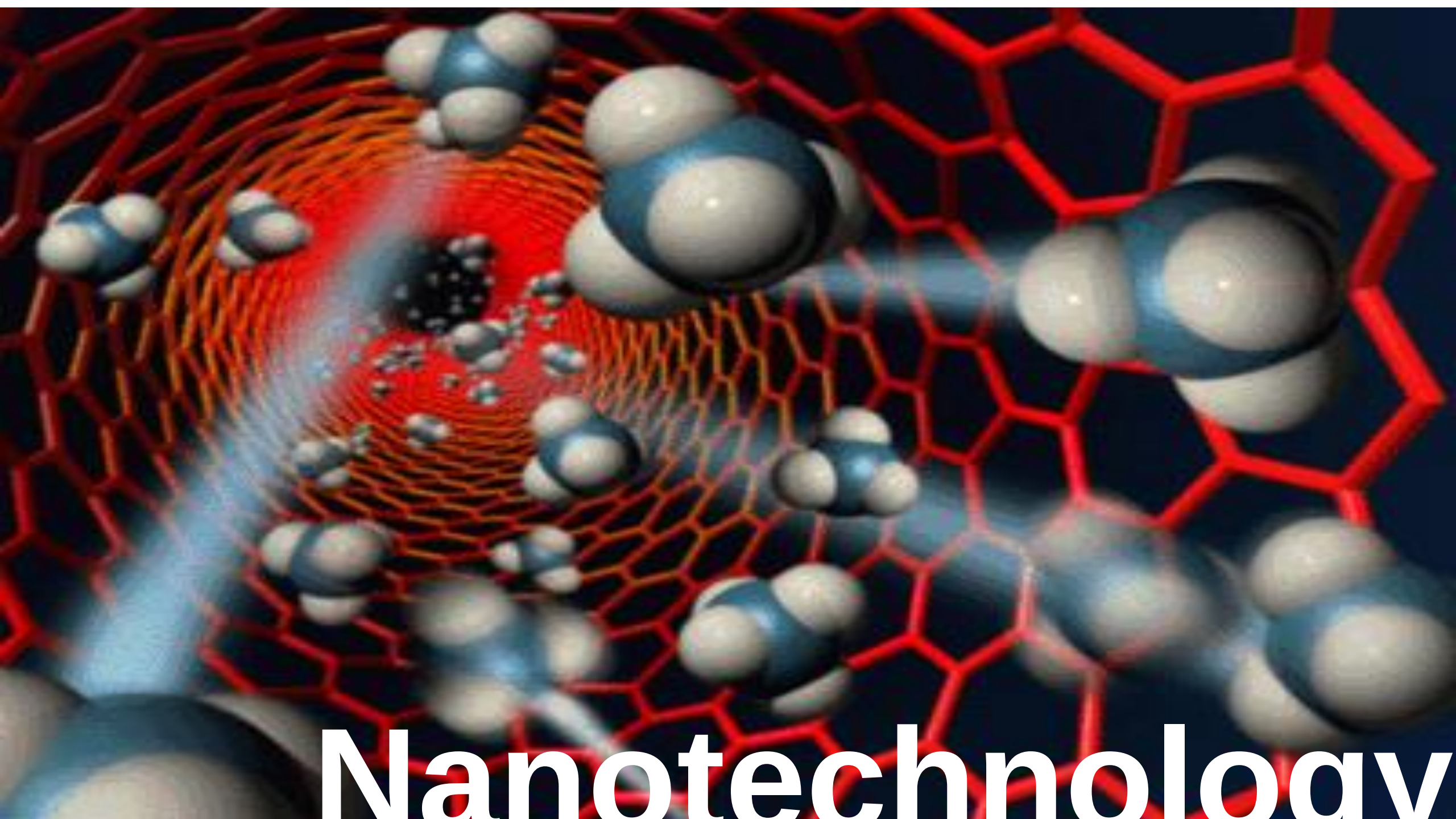


USDA ORGANIC

SYN BIO FREE

MADE WITH SAFE INGREDIENTS
MADE SAFE
WWW.MADESAFE.ORG

International Organic and Natural Cosmetics Corporation
BDIH Standard
COSMOS ORGANIC


Nanotechnology

Nanotechnology is engineering at the scale of 1 nanometer:

One billionth of meter - about 3 carbon atoms.

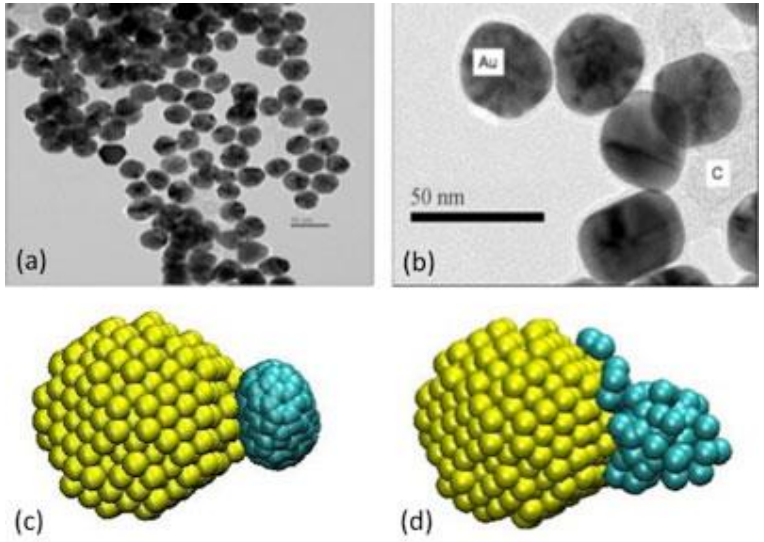
(DNA is about 8 atoms wide)

Everything is built at the nanoscale

precise control of the atoms and molecules

Matter changes properties at the nanoscale

changes in colour, strength, conductivity, reactivity etc.



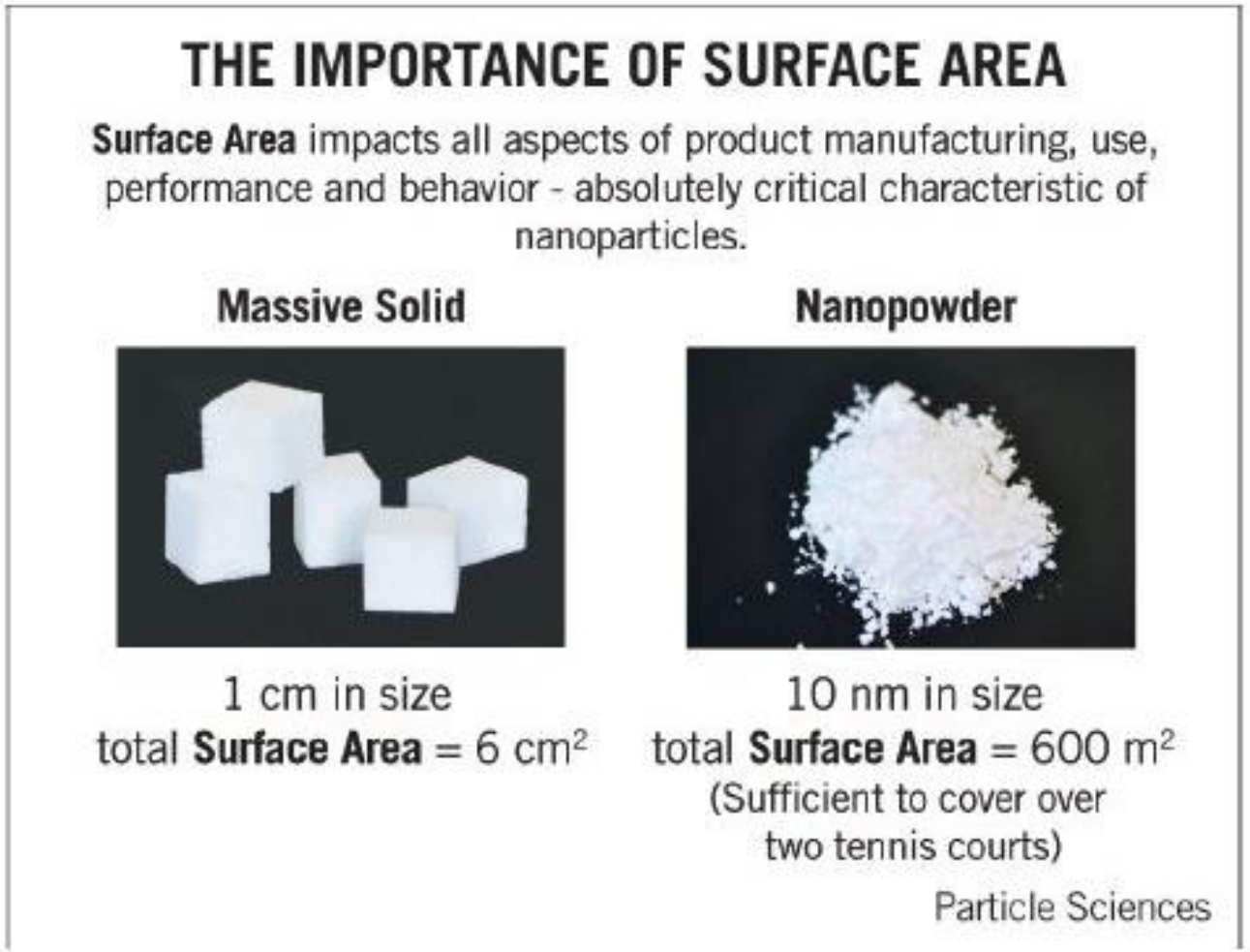
Nanotechnologists engineer novel

NANOPARTICLES and NANOMATERIALS

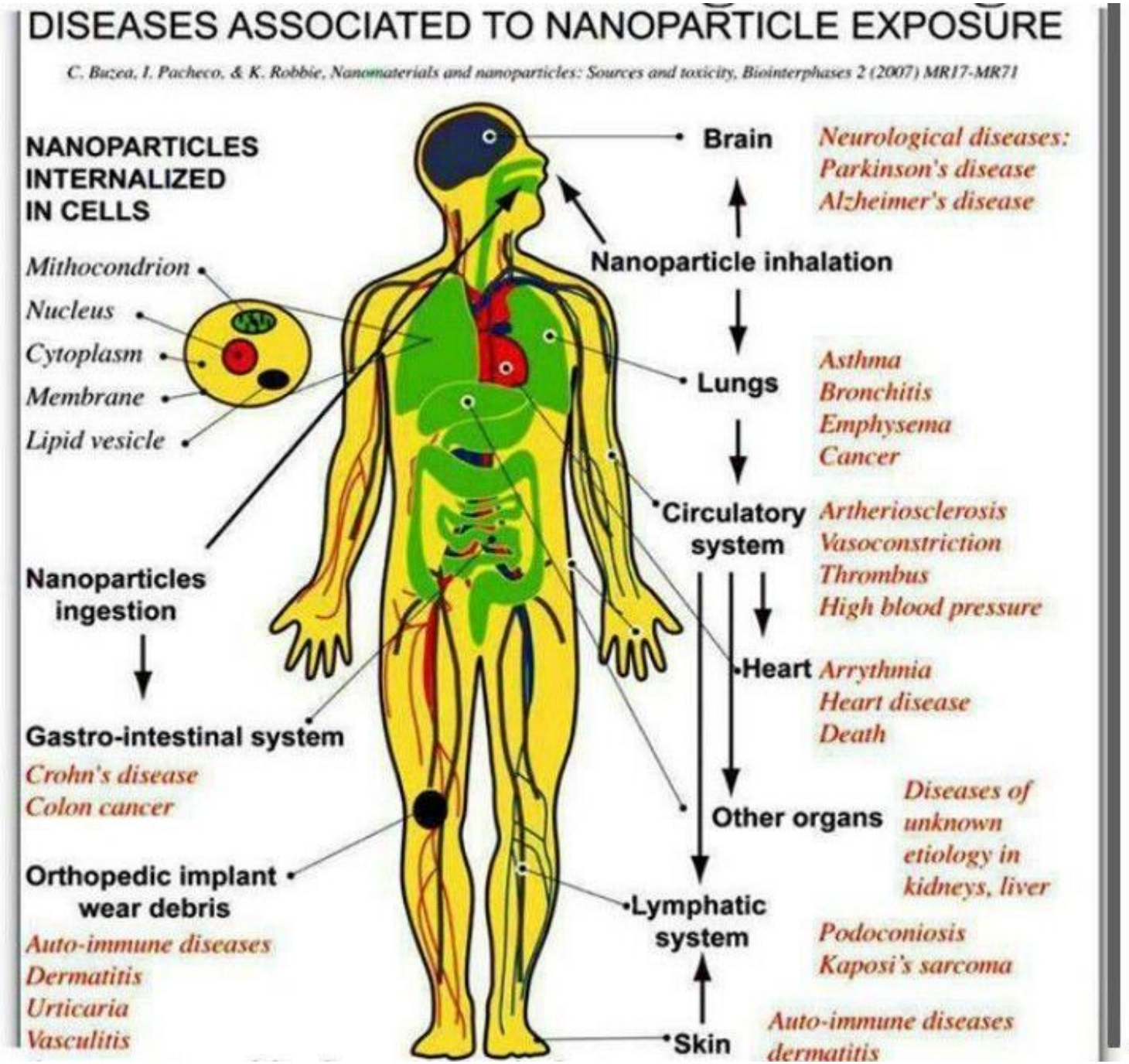
Small clumps of matter with industrially useful properties

New properties = new toxicity

Nanoparticles have large surface area – greater reactivity/toxicity



Nanoparticles move easily through the body




NANO SILVER

Environmental Health NEWS

Silver nanoparticles stop sperm stem cell growth.

Sep 01, 2010

Braydich-Stolle, LK, B Lucas, A Schrand, RC Murdock, T Lee, J Schlager, S Hussain, and M-C Hofmann. 2010. **Silver nanoparticles disrupt GDNF/Fyn kinase signaling in spermatogonial stem cells**. Toxicological Scences http://dx.doi.org/10.1093/toxsci/kfq148.

Synopsis by Jennifer F. Nyland

A new study has identified exactly how silver nanoparticles cause male reproductive cells to stop growing.

Minute materials used in a number of consumer products such as antimicrobial agents can interrupt important cell signaling within male reproductive sperm cells, causing them to stop growing, according to a new study that builds on previous work by the same research group.

In prior studies, the scientists reported how smaller-sized silver nanoparticles – in the 10 - 25 nanometer range – decreased the growth of male stem cells when they were exposed at concentrations greater than 10 micrograms per milliliter (µg/ml).

The new study is the first to identify how the silver nanoparticles stop the sperm stem cells from growing. The biggest effects were caused by the smallest-sized nanoparticles tested.

This study raises important questions about potential effects on male fertility, because silver nanoparticles are currently used in a wide range of products.

In addition, exposure during development may affect forming sperm cells and lead to birth defects related to the male reproductive system. Scientists believe this is because the small silver particles can cross the mother's placenta and directly affect the baby.

Iranian Journal of Reproductive Medicine
IJRM
Yazd Reproductive Sciences Institute
Shahid Sadoughi University of Medical Sciences and Health Services

Iran J Reprod Med. 2013 Sep; 11(9): 767–771.
PMCID: PMC3941329

Effect of zinc oxide nanoparticles on viability of human spermatozoa

Abolfazl Barkhordari, Ph.D.,[1] Seyedhossein Hekmatimoghaddam, M.D.,[2] Ali Jebali, Ph.D.,[3] Mohammad Ali Khalili, Ph.D.,[4] Alireza Talebi, Ph.D.,[4] and Marzieh Noorani, M.Sc.[5]

Author information ► Article notes ► Copyright and License information ►

Abstract

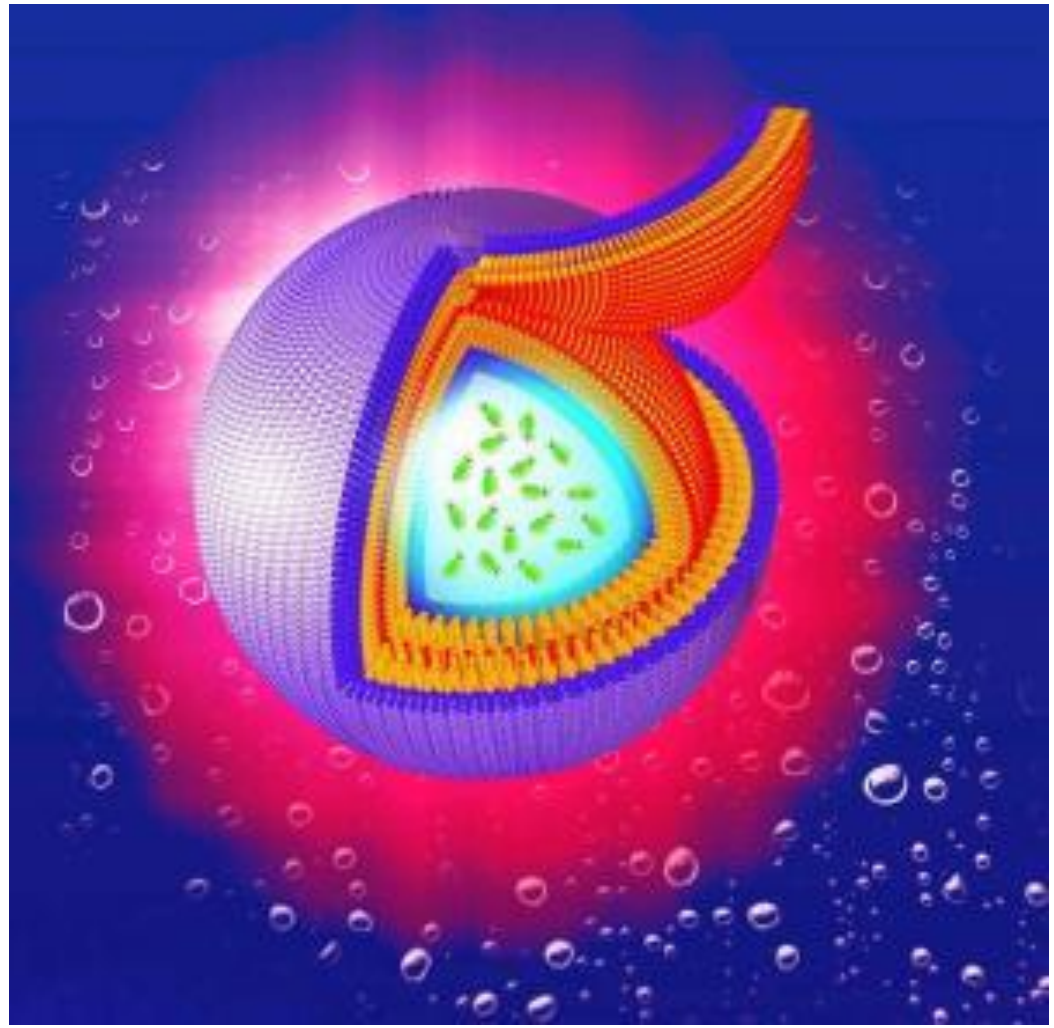
Go to:

Background: The extensive use of different nanoparticles has raised great concerns about their occupational and biological safety.

Objective: The aim of this study was to evaluate the cytotoxic effect of zinc oxide nanoparticles (ZnO NPs) on viability of spermatozoa.

Materials and Methods: Semen samples were obtained from 15 healthy persons, and were analyzed using WHO guidelines. Each semen sample was separately incubated with different concentrations of ZnO NPs (10, 100, 500, and 1000 µg/mL) at 37°C for 45, 90, and 180 minutes. Then, the cell death percentage of spermatozoa was measured by MTT assay. Mann-Whitney test was used for comparison of different times and concentrations.


O2BLOCK



The European Union Scientific Committee on Consumer Safety (SCCS) finds that needle-like nano-hydroxyapatite — one of the nanomaterials we found in Gerber®, Well Beginnings™, and Enfamil™ formulas — is potentially toxic, could be absorbed by and enter cells, and should not be used in cosmetics such as toothpaste, teeth whiteners and mouth washes. A material that should not be used in cosmetics raises greater concern when used in food.

Nanoparticles found in popular baby formulas tested by Friends of the Earth

Baby Formula Brand	Nanoparticles Found
Gerber® Good Start® Gentle	Nano-hydroxyapatite (nano HA)
Gerber® Good Start® Soothe	Titanium dioxide and silicon dioxide (limited amount of particles detected)
Enfamil™	Nano-hydroxyapatite (nano HA) in needle-like and non needle-like form
Similac® Advance® OptiGRO™ (liquid)	Titanium dioxide (nano TiO2 laboratory results inconclusive)
Similac® Advance® OptiGRO™ (powder)	Nano silicon dioxide (laboratory results inconclusive)
Well Beginnings™ Advantage®	Nano-hydroxyapatite (nano HA)

MEPs vote for moratorium on nanoparticles in food

Environment and health committee calls for the Commission to go back to the drawing board in revising 1997 regulation covering new food types.

EUROPEAN VOICE
By **DAVE KEATING** | 11/25/14, 12:00 AM CET | Updated 11/26/14, 6:49 PM CET

Members of the European Parliament's environment and health committee voted tonight (24 November) to reject a proposal from the European Commission that would have updated existing European Union rules on so-called 'novel foods' to allow the use of nanoparticles.

Such particles are not covered in the existing 1997 legislation on novel foods – foods which use new technologies in their use or composition. In their position adopted tonight, MEPs on the European Parliament's environment committee adopted a position that would set a moratorium on nano-foods until nano-specific risk assessment methods have been approved for use by the European Food Safety Agency (EFSA).

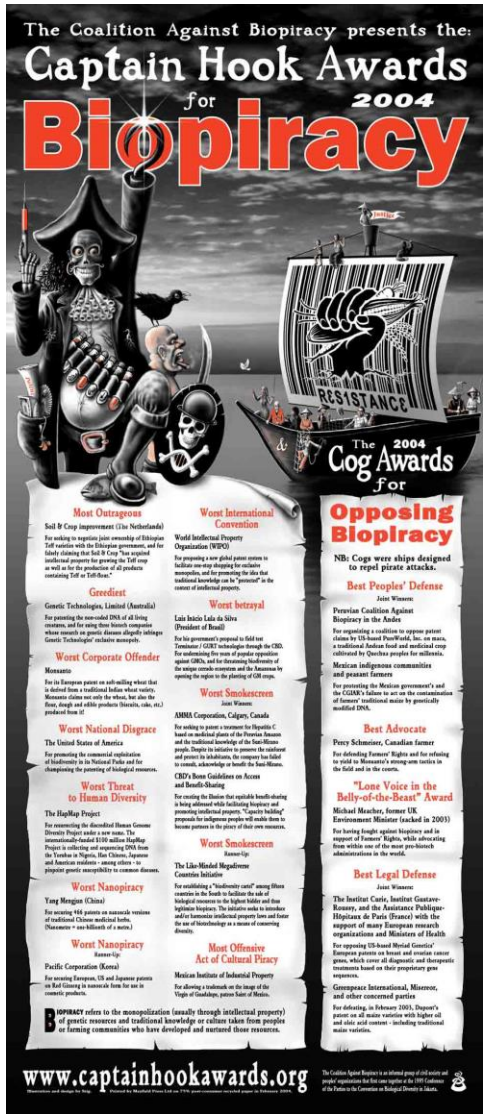
Good News: EPA Requires Nanomaterials Data

January 13, 2017 | Jennifer Sass

Are there nanomaterials in your closet? If you don't know the answer, you may soon—thanks to a new U.S. Environmental Protection Agency (EPA) rule.

Nanomaterials consist of smaller-than-microscopic chemicals, and they're used in clothing, agrochemicals, sports equipment and all sorts of other consumer goods. Nanomaterials are used in products from all commercial sectors. (Look at this searchable Consumer Products Inventory for more detail on that).

EPA this week finalized its **Rule on Nanomaterials Reporting and Recordkeeping**. This gives the agency the power to require companies that manufacture, import, or process nanoscale chemicals to "fess up" about these materials. It allows EPA to require these companies to disclose what they are making, how much, whether it is being released into



Worst Nanopiracy
Yang Mengjun (China)

For securing 466 patents on nanoscale versions of traditional Chinese medicinal herbs by simply turning traditional plants into fine powders with particles under 100 nanometres (one nanometre = one-billionth of a metre) and claiming a new invention with increased solubility and bioavailability.[18] Mr. Yang has secured monopoly patents on barks, roots, fruit, and leaves that have been used in Chinese medicine since ancient times. Mr. Yang has secured monopoly patents on barks, roots, fruit, and leaves that have been used in Chinese medicine since ancient times. Mr. Yang appears to be the largest single holder of nanopatents in the world.[19] A new way to monopolize traditional knowledge!

Worst Nanopiracy – Runner-Up:
Pacific Corporation (Korea)

For securing European, US and Japanese patents on Red Ginseng in nanoscale form for use in cosmetic products.[21] Pacific corporation has reduced Red Ginseng to a nano-emulsion of small particles between 50-500nm that can pass across the skin and exert an anti-aging effect. Pacific corporation is now claiming intellectual molecular monopoly over an herb that has been cultivated and used medicinally since ancient times.


NEXT STEPS

Some next steps for companies? – narrow picture on Syn Bio/ nano.

1) **Start mapping whether your supply chain is affected** by synbio (and nano!). Use the SynBio-free companies Guide and Database. Request affidavits etc.

2) **Don't mislead consumers** about synbots or synbio – if its artificial/ Syn Bio say so. 'nature identical' means not natural.

3) Even better avoid them and **commit to syn-bio free**.

And for the industry:

> Join with **Natural Products Working Group on GMO 2.0**

- Urgent need for a conversation with so-called 'natural' **certifiers** who allow synbio ingredients under their certification – Big Trust issue: Dilution/debasement of Natural Products.
- Urgent need to develop **testing and identification methods**
- **Communication** to consumers and within industry
- Participate in national and international **political/regulatory** processes as a different industry voice – eg UN Convention on Biodiversity, FAO, FDA

Ref.: SCBD/SPS/DC/DA/MW/86375 16 March 2017

NOTIFICATION

Submission of information on synthetic biology and nomination of experts to participate in the Open-ended Online Forum on Synthetic Biology

Dear Madam/Sir,

In decision XIII/17, the Conference of the Parties to the Convention on Biological Diversity commended the work of the online forum and the Ad Hoc Technical Expert Group on Synthetic Biology (AHTEG), and welcomed the conclusions and recommendations of the report of the AHTEG as a basis for further discussion.

The Conference of the Parties decided to extend the mandate of the AHTEG in accordance with the terms of reference annexed to the decision and also to contribute to the completion of the assessment as requested in paragraph 2 of decision XII/24.

The Conference of the Parties also decided to extend the open-ended online forum to support the work of the AHTEG, and invited Parties, other Governments, indigenous peoples and local communities and relevant organizations to continue nominating experts to take part in the open-ended online forum.

Some next steps for the industry: Big Picture on Technology and Values

1) Start a conversation/research into **technological trends** that will impact this industry – especially in the context of 4th Industrial revolution: Syn Bio, Nano, Artificial intelligence, Automation/robotics, CAOS, Drone delivery, internet of things, Molecular communication.
2) How can Natural Products Industry support **Technology Assesment?**
   - within industry, with consumers, with civil society
   - at national and international level?

Two initiatives:

- TAPS – Technology Assesment Platforms
- GOATS – Global Overview Assesment of Technological Systems

This is a great opportunity to align with both farmers and consumers in defence of natural products and botanicals.. To build a vision of health, justice and livelihoods together right through the food chain.

Natural not Synthetic

Grown by Real Farmers not synthetic organisms

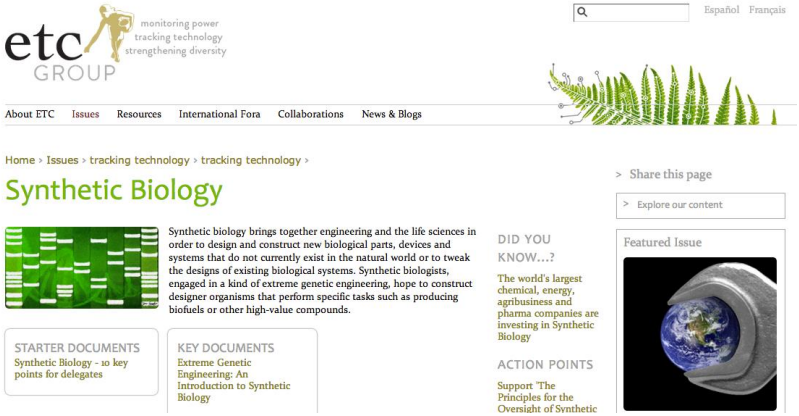
Developed from People's wisdom not artificial intelligence

Supporting sustainable use of living biodiversity not its destruction/replacement.

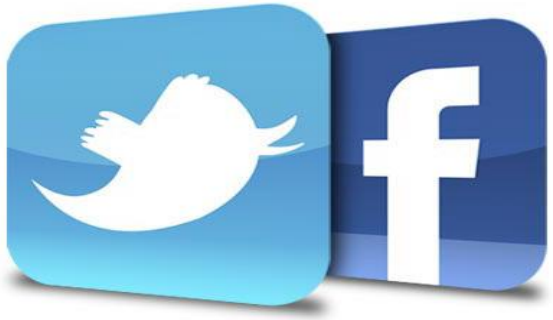
www.synbiowatch.org

http://database.synbiowatch.org

more on Syn Bio?



www.etcgroup.org/issues/syntheticbiology



@etc_group @synbiowatch @jimetc

E: Jim@etcgroup.org