Introduction to Bioengineering
BIOE/ENGR.80
Stanford University

Spring 2020 Class Slides

Day 5
15 April 2020

POPULATION OF THE EARTH

Allianz

Number of people living worldwide since 1700 in billions

ENGINEERING

2048: **9 bln**

2024: **8 bln**

1999: **6 bln**

2012: **7 bln**

1987: **5 bln**

1960: **3 bln**

1974: **4 bln**

1927: **2 bln**

1700 1800 1900 2000

Source: United Nations World Population Prospects, Deutsche Stiftung Weltbevölkerung

For further information please visit: www.knowledge.allianz.com

The New York Times

George the Snail, Believed to Be the Last of His Species, Dies at 14 in Hawaii

This snail, named George, died on Jan. 1. Scientists believe he was the last of his species, which was native to the Hawaiian island of Oahu.

Hawaii Department of Land and Natural Resources

By Julia Jacobs

Jan. 10, 2019

RESEARCH ARTICLE

ENVIRONMENTAL SCIENCES

Accelerated modern human–induced species losses: Entering the sixth mass extinction

10.1126/sciadv.1400253

Gerardo Ceballos,[1]* Paul R. Ehrlich,[2] Anthony D. Barnosky,[3] Andrés García,[4] Robert M. Pringle,[5] Todd M. Palmer[6]

The oft-repeated claim that Earth's biota is entering a sixth "mass extinction" depends on clearly demonstrating that current extinction rates are far above the "background" rates prevailing between the five previous mass extinctions. Earlier estimates of extinction rates have been criticized for using assumptions that might overestimate the severity of the extinction crisis. We assess, using extremely conservative assumptions, whether human activities are causing a mass extinction. First, we use a recent estimate of a background rate of 2 mammal extinctions per 10,000 species per 100 years (that is, 2 E/MSY), which is twice as high as widely used previous estimates. We then compare this rate with th

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Since 1900 alone, 69 mammal species are believed to have gone extinct, along with about 400 other types of vertebrates. Evidence for species lost among nonvertebrate animals and other kinds of living things is much more difficult to come by, the researchers say, but there's little reason to believe that the rest of life on Earth is faring any better.

- Land clearing for farming, logging and settlement
- Introduction of invasive species
- Carbon emissions that drive climate change and ocean acidification
- Toxins that alter and poison ecosystems

Loss of habitat due to changing land use

http://thebreakthrough.org/index.php/programs/conservation-and-development/can-palm-oil-deforestation-be-stopped

Natural species in new places

http://www.nbcnews.com/news/other/two-thousand-mice-dropped-guam-parachute-kill-snakes-f2D11685572

Global impacts of industrialization

CNN World + Live TV U.S. Edition + menu

Study: Over 90% of Great Barrier Reef suffering from coral bleaching

By **Euan McKirdy, CNN**

Updated 8:47 AM ET, Wed April 20, 2016

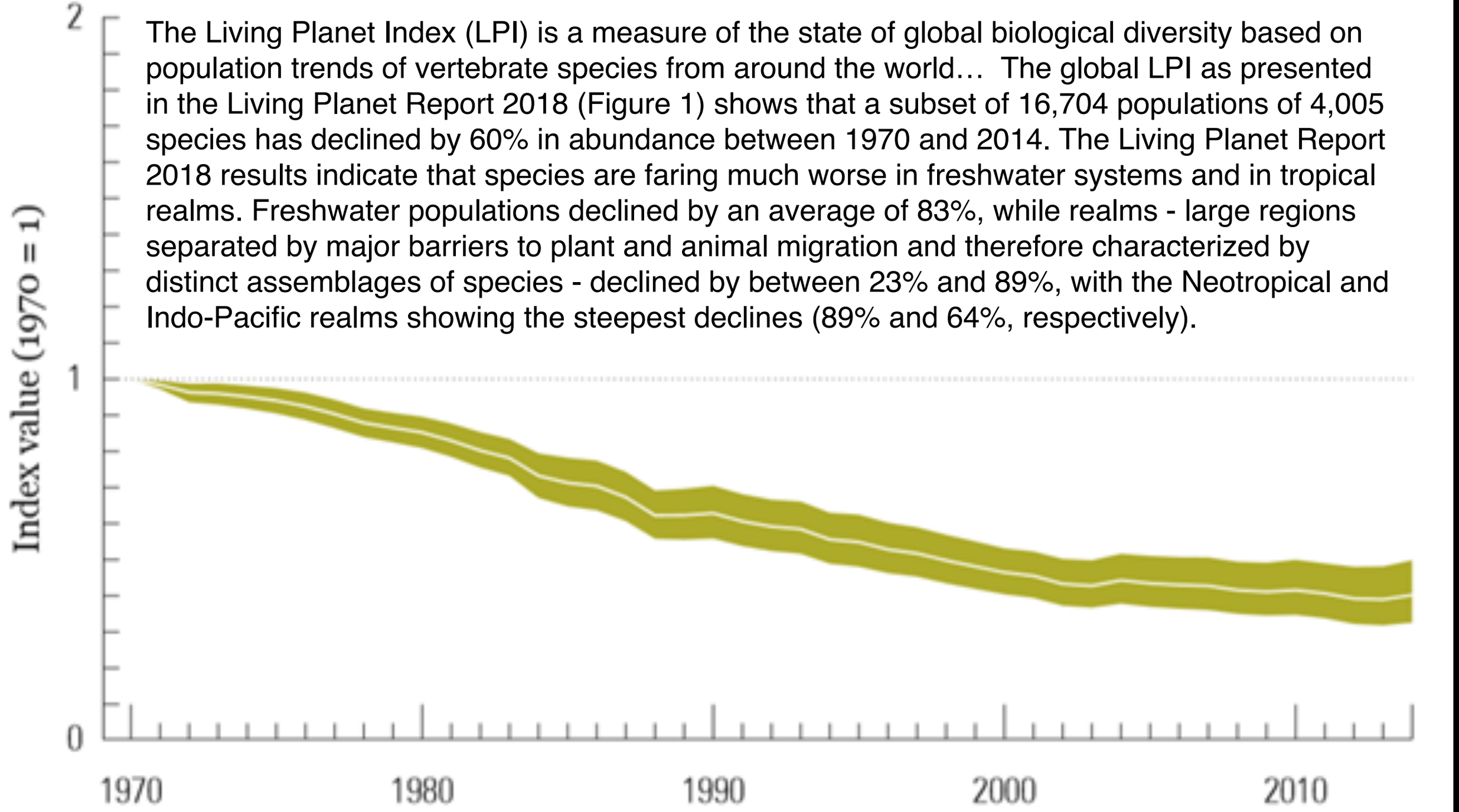
9 photos: Australia's Great Barrier Reef suffers 'extreme' coral bleaching

Some of the bleaching of reefs in the northern section has been described as "extreme."

http://www.cnn.com/2016/04/20/asia/great-barrier-reef-coral-bleaching/

Past ~50 years, humans x 2, animals / 2

The Living Planet Index (LPI) is a measure of the state of global biological diversity based on population trends of vertebrate species from around the world… The global LPI as presented in the Living Planet Report 2018 (Figure 1) shows that a subset of 16,704 populations of 4,005 species has declined by 60% in abundance between 1970 and 2014. The Living Planet Report 2018 results indicate that species are faring much worse in freshwater systems and in tropical realms. Freshwater populations declined by an average of 83%, while realms - large regions separated by major barriers to plant and animal migration and therefore characterized by distinct assemblages of species - declined by between 23% and 89%, with the Neotropical and Indo-Pacific realms showing the steepest declines (89% and 64%, respectively).



http://www.livingplanetindex.org/projects?main_page_project=AboutTheIndex&home_flag=1

It's getting worse...

Poachers Kill More Rhinos as Coronavirus Halts Tourism to Africa

Threatened and endangered animals may become additional casualties of the pandemic.

white rhino was placed in a Rhino 911 helicopter for rehabilitation in th West province on March 8. Nico Jacobs

By Annie Roth

April 8, 2020

31

The past few weeks have not been easy for Nico Jacobs, founder of Rhino 911, a nonprofit that provides emergency helicopter transport for rhinoceroses in need of rescue in South Africa. That's because times are much worse for the rhinos.

Since South Africa announced a national lockdown on March 23 to limit the spread of the new coronavirus, Mr. Jacobs has had to respond to a rhino poaching incident nearly every day. On March 25, he rescued a 2-month-old white rhino calf whose mother had been killed by poachers. The next day he was called to rescue two black rhinos whose horns had been hacked off by poachers. When he finally tracked them down it was too late — both were dead.

"Just as soon as the lockdown hit South Africa, we started having an incursion almost every single day," Mr. Jacobs said.

https://www.nytimes.com/2020/04/08/science/coronavirus-poaching-rhinos.html

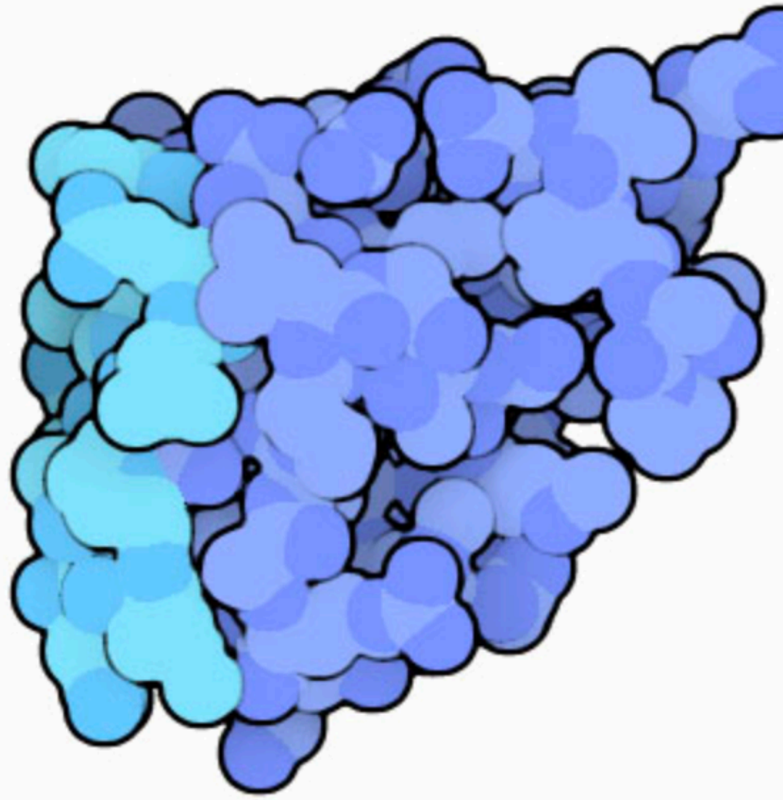
What do you think?

Should bioengineers care about natural biodiversity?

Antifreeze Proteins

Small antifreeze proteins protect cells from damage by ice

Ice is a big problem for organisms that live in cold climates. Once the temperature dips below freezing, ice crystals steadily grow and burst cells. This danger, however, has not limited the spread of life on Earth to temperate regions. Organisms of all types--plants, animals, fungi and bacteria--have developed ways to combat the deadly growth of ice crystals. In some cases, they pack their cells with small antifreeze compounds like sugars or glycerol. But in cases where extra help is needed, cells make specialized antifreeze proteins to protect themselves as the temperature drops.



Antifreeze protein from the cold-water ocean pout, with the ice-binding portion in lighter blue.

Download high quality TIFF image

Nice Ice

Antifreeze proteins don't stop the growth of ice crystals, but they limit the growth to manageable sizes. For this reason, they are also known as ice-restructuring proteins. This is necessary because of an unusual property of ice called recrystallization. When water begins to freeze, many small crystals form, but then a few small crystals dominate and grow larger and larger, stealing water molecules from the surrounding small crystals. Antifreeze proteins counteract this recrystallization effect. They bind to the surface of the small ice crystals and slow or prevent the growth into larger dangerous crystals.

Supercooling

Antifreeze proteins lower the freezing point of water by a few degrees, but surprisingly, they don't change the melting point. This process of depressing the freezing point while not effecting the melting point is termed *thermal hysteresis*. The most effective antifreeze proteins are made by insects, which lower the freezing point by about 6 degrees. However, antifreeze proteins, even the ones from plants and bacteria that have smaller effects on freezing point, are useful in another way. They are placed outside cells where they control the size of ice crystals and prevent catastrophic ice crystal formation when the temperature drops below the (lowered) freezing point.

FOOD

Creamy, Healthier Ice Cream? What's the Catch?

By JULIA MOSKIN JULY 26, 2006

IN its quest to create ice cream as voluptuous as butter and as virtuous as broccoli, the ice cream industry has probed the [illegible] studied the intimate structures of algae and fois[illegible] the American public.

"I have tried them all as they came down the pil[illegible] sugar-free; with tofu, yogurt, rice, whatever," sa[illegible] who lives near Flagstaff, Ariz., cataloguing the [illegible] tasted over the years. "They always make me sa[illegible]

For Americans who spend each summer wrestli[illegible] fresh hope in the freezer case. New industrial pr[illegible] involves a protein cloned from the blood of an A[illegible] allowed manufacturers to produce very creamy, [illegible] creams with fewer additives. The new products [illegible] acquired a taste for superpremium high-fat ice [illegible] its fat content.

But using new technologies can be risky for manufacturers. The other new method for making supercreamy ice cream was caught up last month in the global debate over genetically modified foods. In June, Unilever, the Anglo-Dutch conglomerate, applied to Britain's Food Standards Agency for permission to use a new ingredient in its frozen desserts — a protein cloned from the blood of an eel-like Arctic Ocean fish, the ocean pout.

Instead of extracting the protein from the fish, which Unilever describes as "not sustainable or economically feasible" in its application, the company developed a process for making it, by altering the genetic structure of a strain of baker's yeast so that it produces the protein during fermentation.

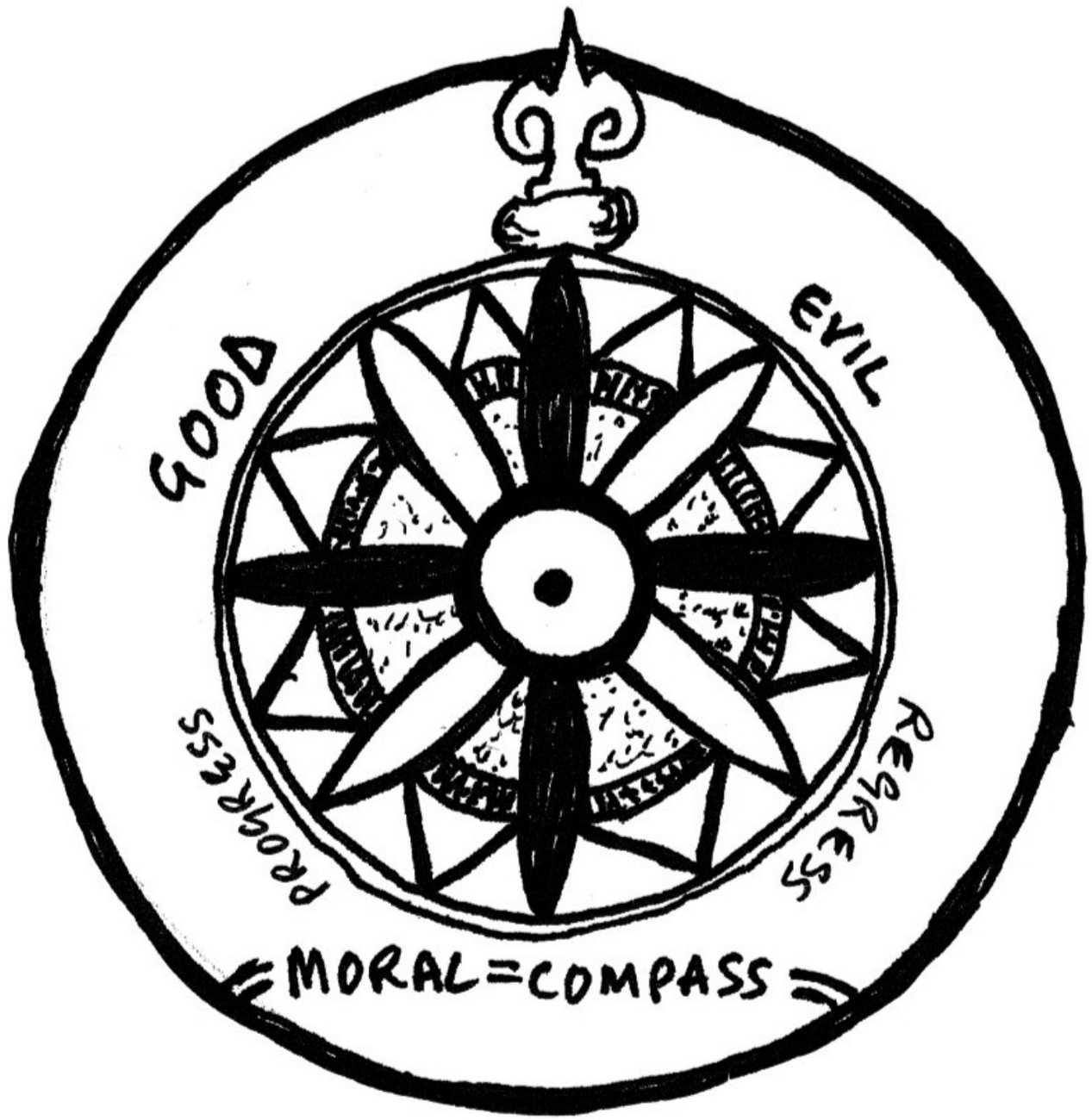
This ingredient, called an ice-structuring protein, has been approved by the Food and Drug Administration and is used by Unilever to make some products in the United States, like some Popsicles and a new line of Breyers Light Double Churned ice cream bars.

"Ice-structuring proteins protect the fish, which would otherwise die in freezing temperatures," said H. Douglas Goff, professor of dairy sciences at the University of Guelph in Ontario. "They also make ice cream creamier, by preventing ice crystals from growing."

Better ice cream? You're welcome!

https://en.wikipedia.org/wiki/Ocean_pout

Generally, how to decide right or wrong?



mor·al com·pass

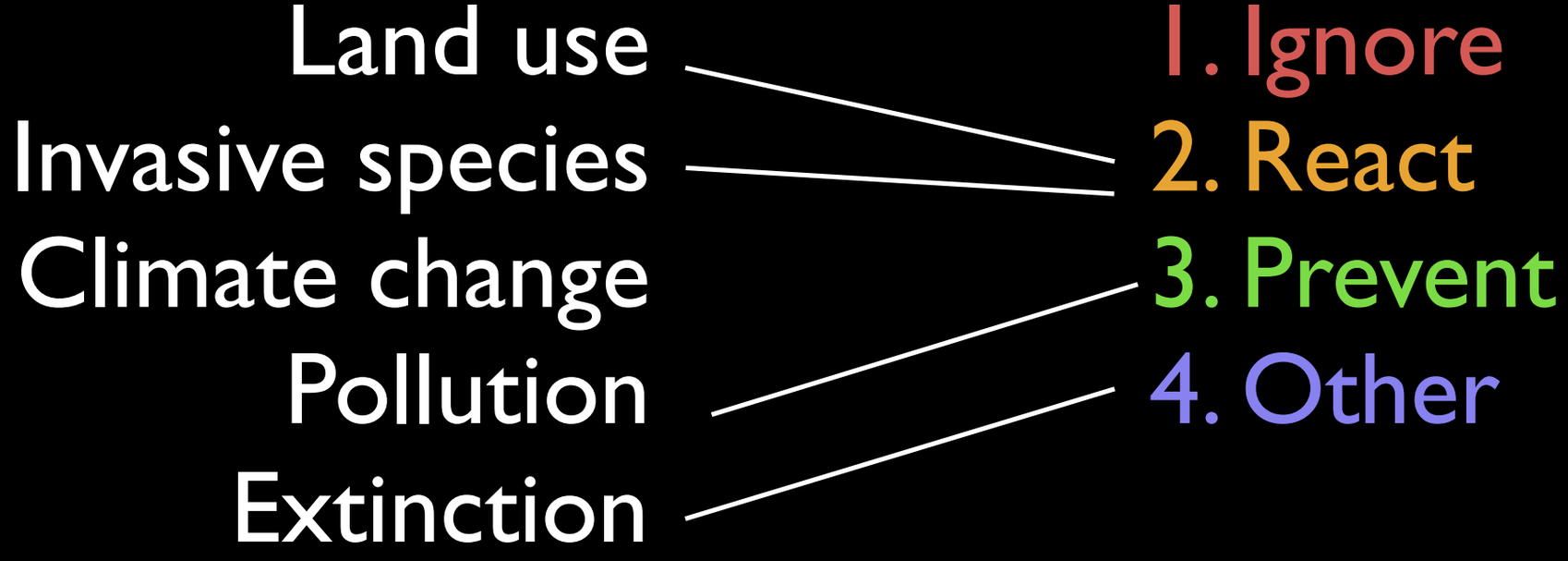
noun

used in reference to a person's ability to judge what is right and wrong and act accordingly.
"he is by no means the only senior politician who has mislaid his moral compass"

Regarding “Planet Health”

Any bioengineering opportunities?

What do you wish for? What do you want to make true by or before 2030?



FRAMESTORM “the question you ask frames the answers you get” — Tina Seelig

Let’s bioengineer back an extinct species?!

http://reviverestore.org/about-the-passenger-pigeon/

http://reviverestore.org/passenger-pigeon-de-extinction-roadmap/

Read the genome of a living, near relative

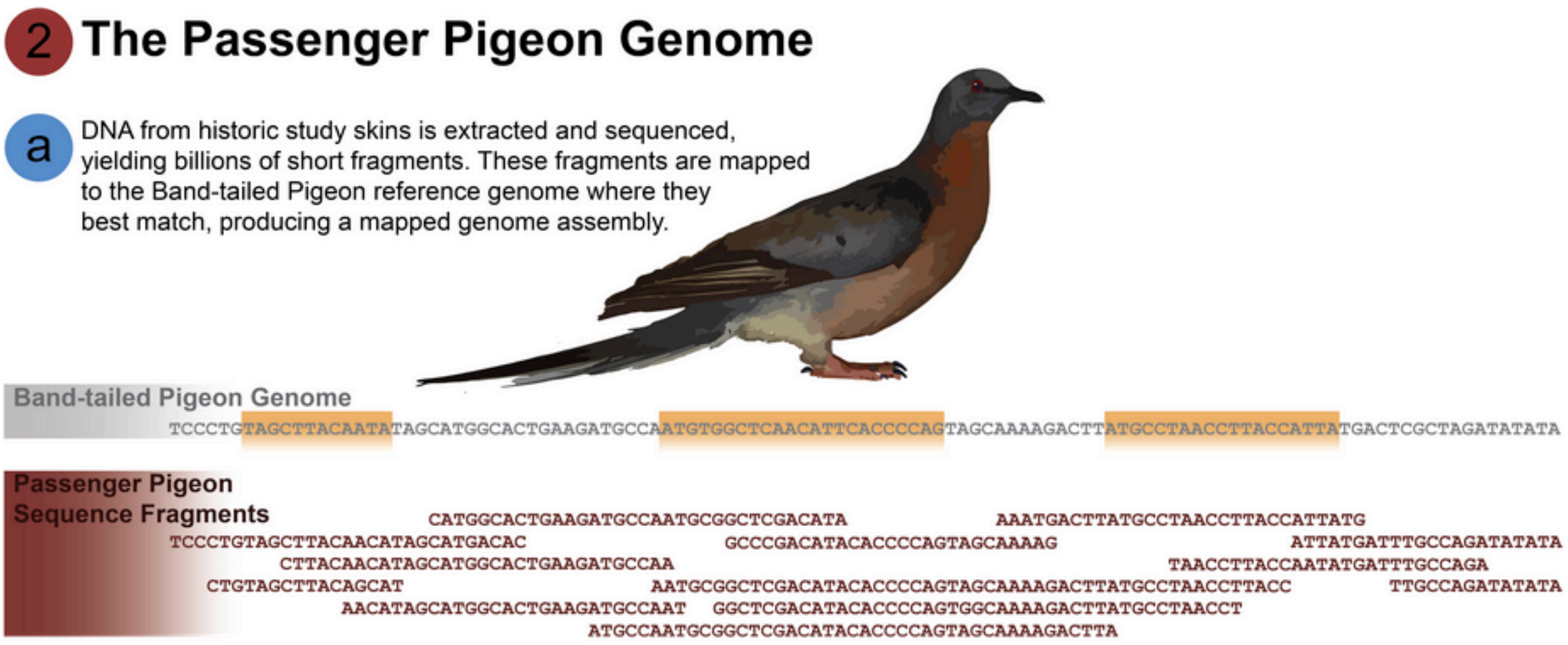
1 The Band-tailed Pigeon Genome

a Genomic code is sequenced and assembled from DNA molecules extracted from Band-tailed Pigeon tissues.

b Genes and regulatory elements, known as the transcriptome, are identified by mapping RNA sequences to the genome.

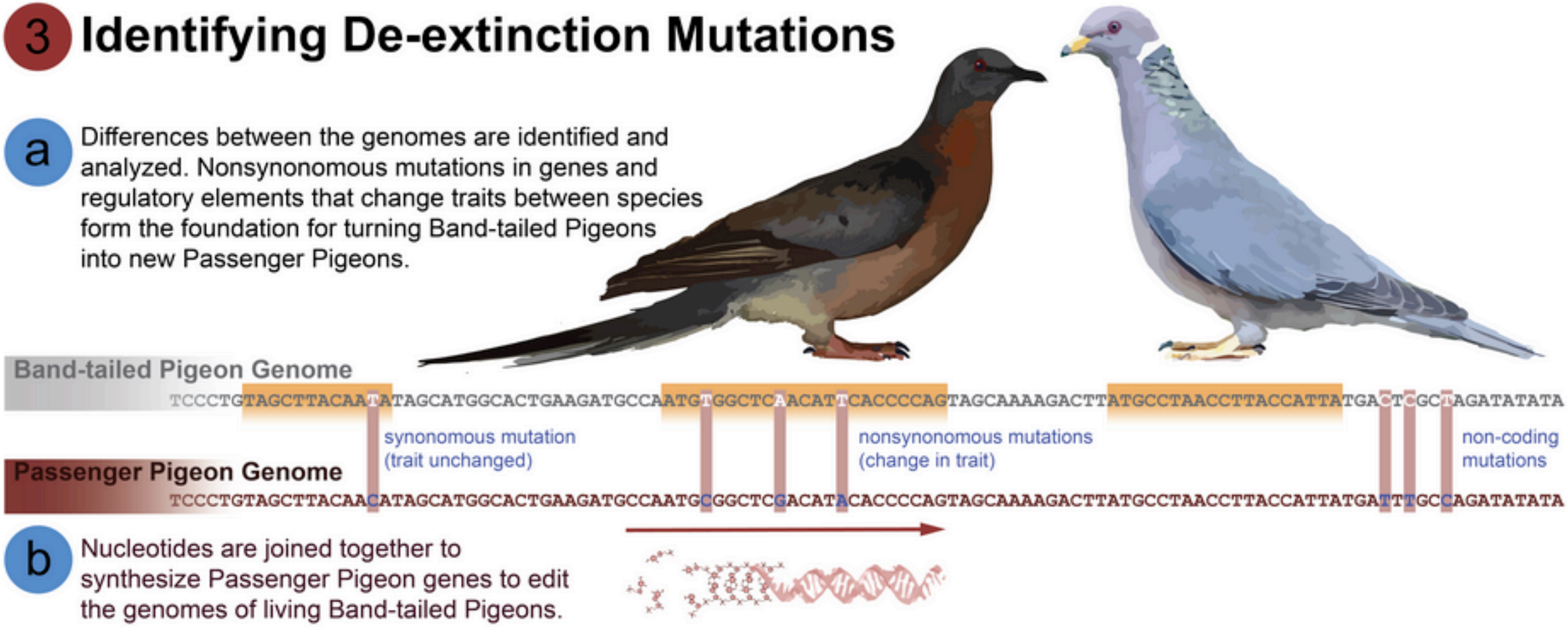
http://reviverestore.org/about-the-passenger-pigeon/

Read the genome of a dead birds



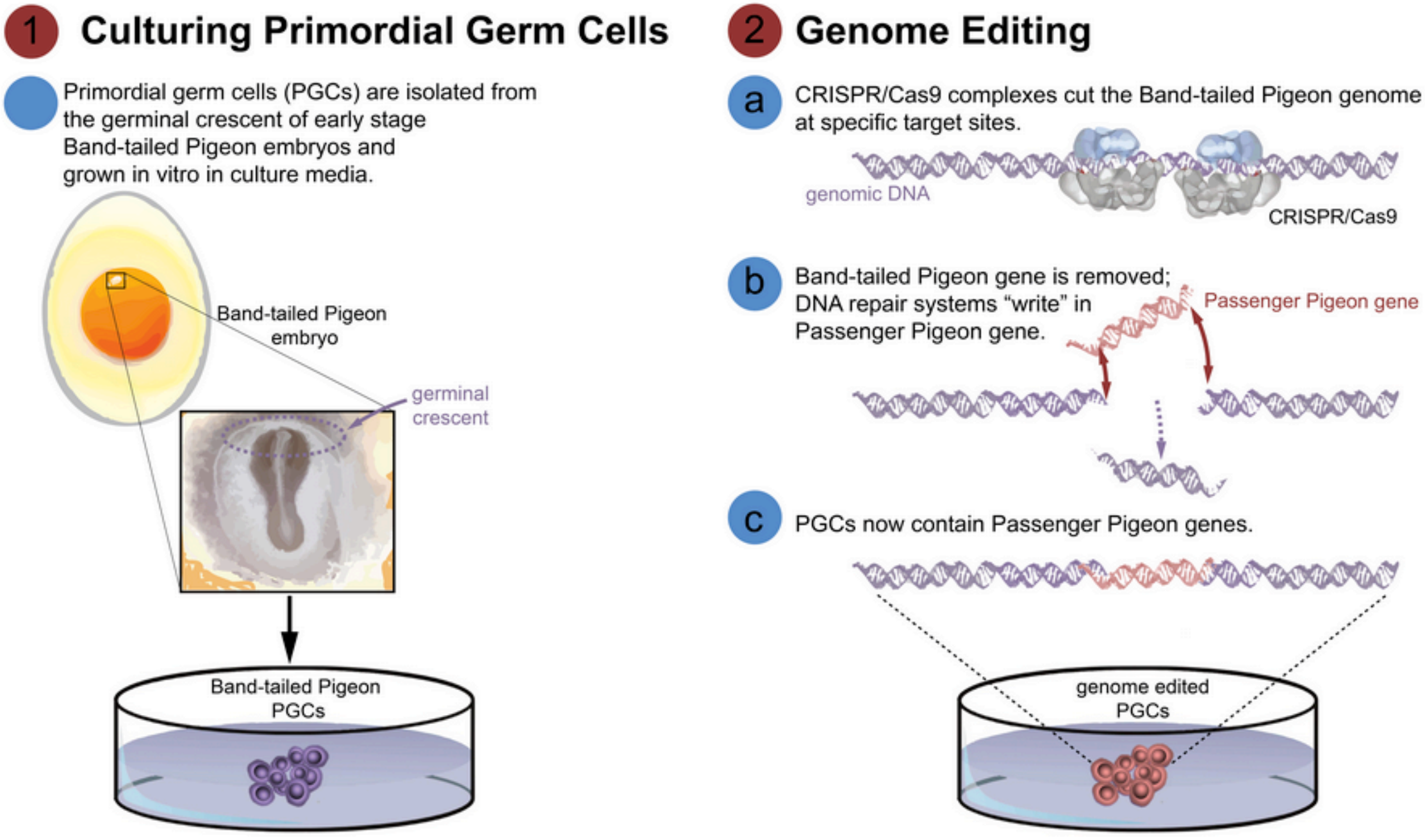
http://reviverestore.org/about-the-passenger-pigeon/

Find differences between two genomes



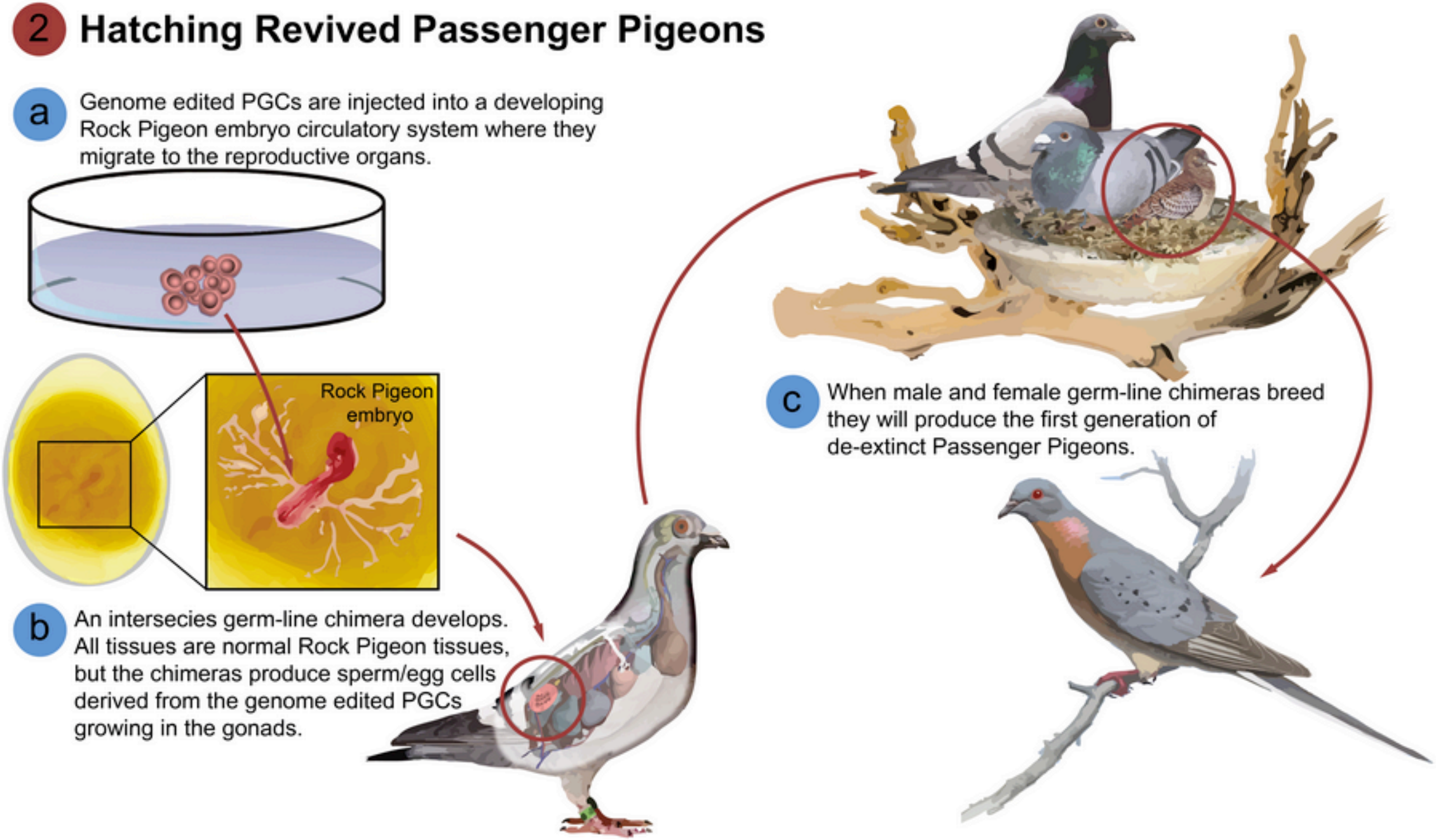
http://reviverestore.org/about-the-passenger-pigeon/

Edit genome to match extinct species'



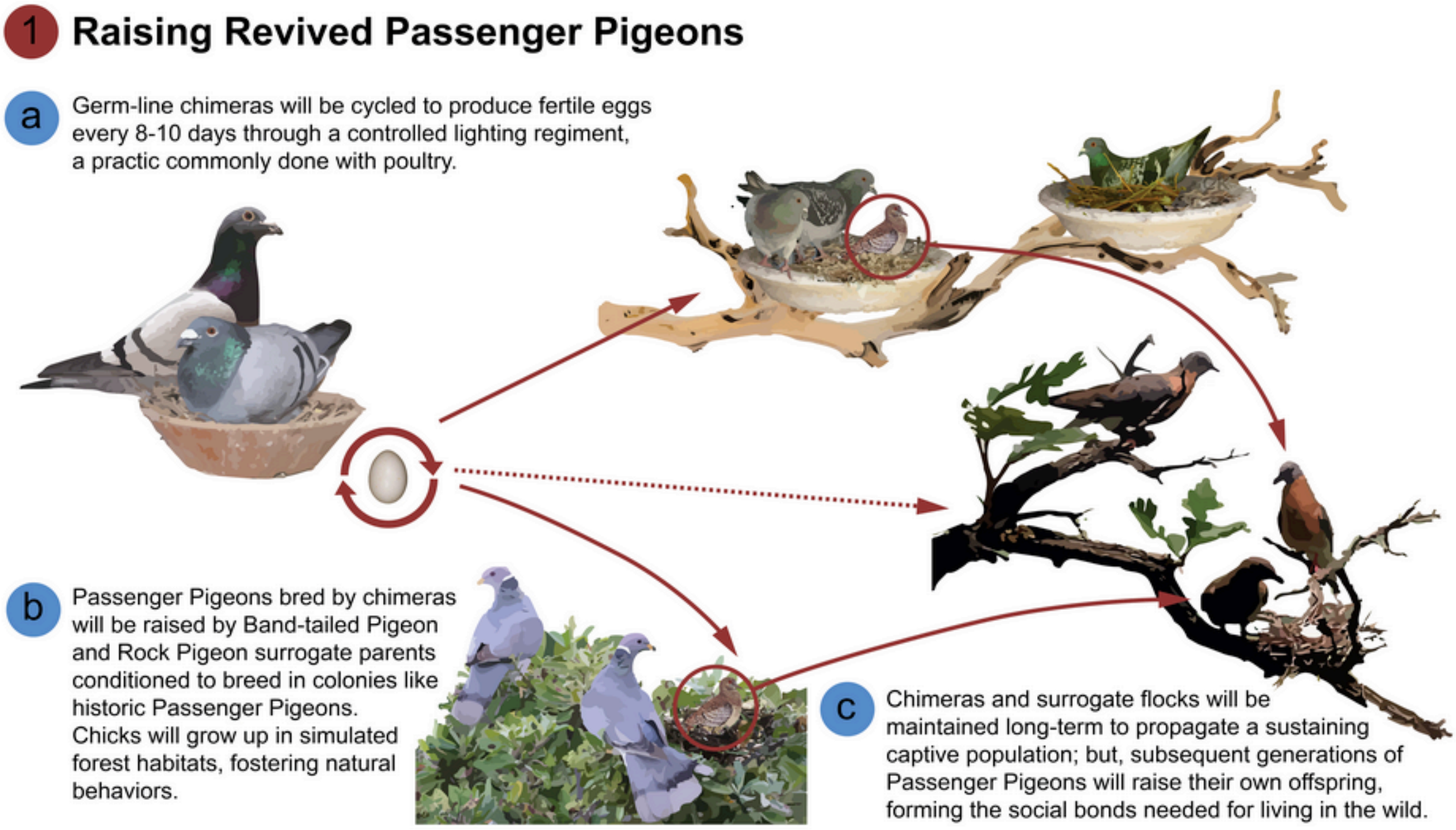
http://reviverestore.org/about-the-passenger-pigeon/

Inject edited DNA into brooding species



http://reviverestore.org/about-the-passenger-pigeon/

Raise revived species, no longer extinct

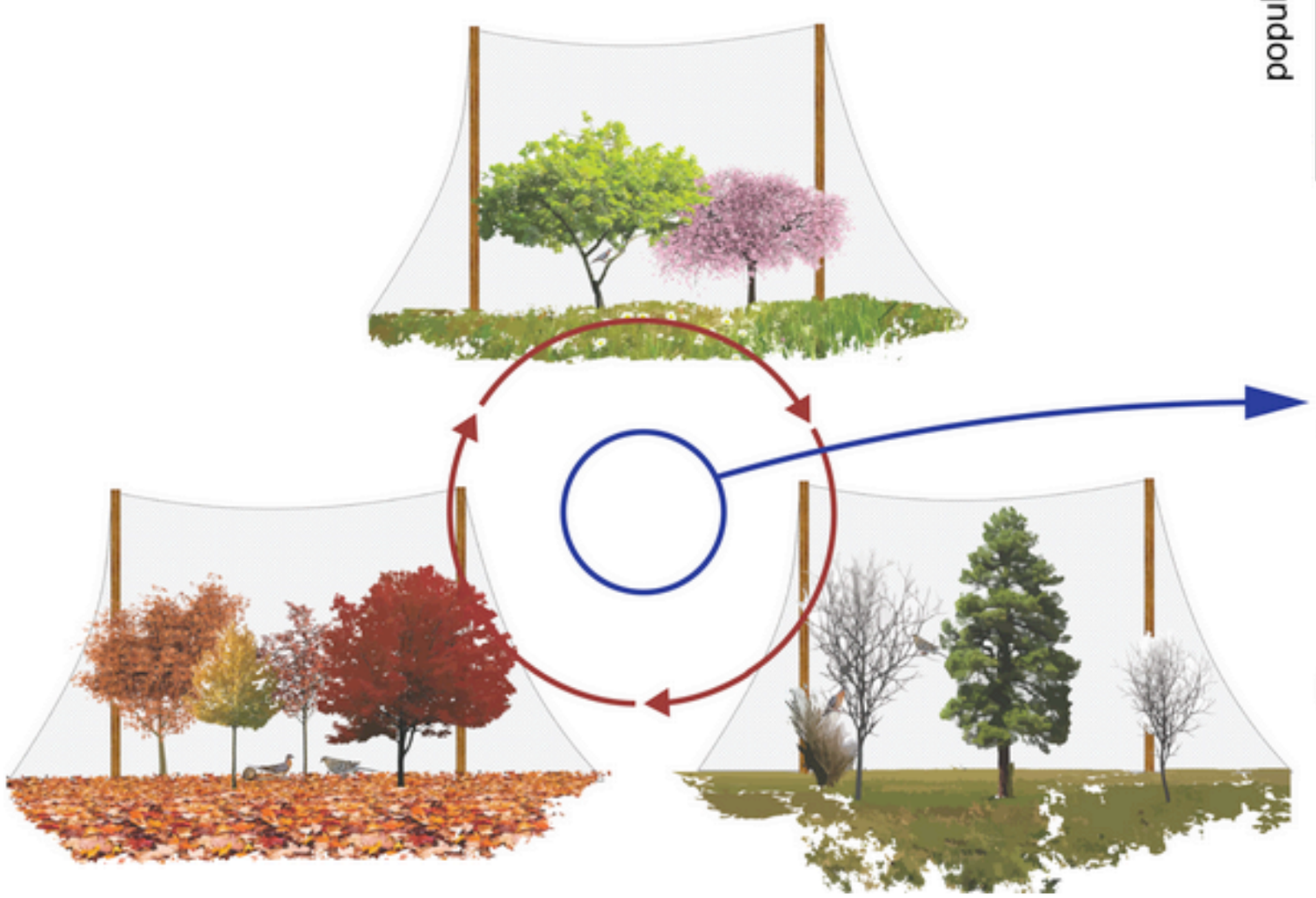


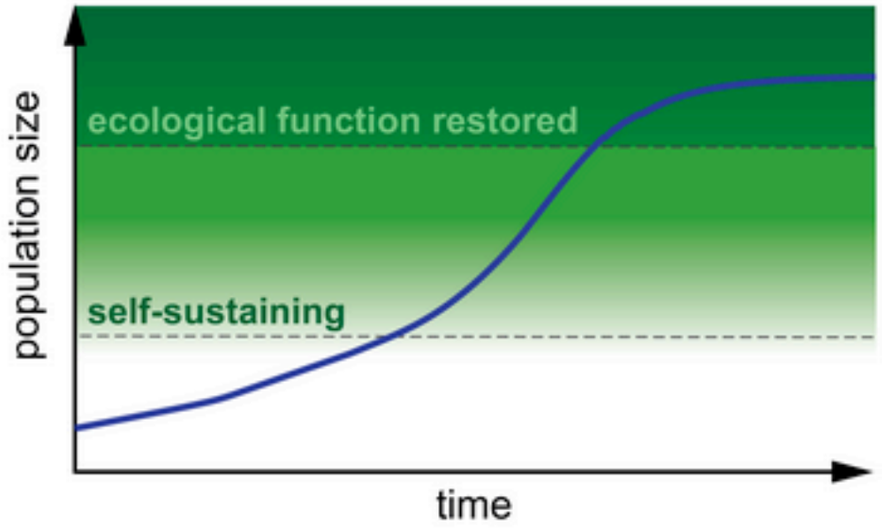
http://reviverestore.org/about-the-passenger-pigeon/

Release revived species into nature

1 Release to the Wild

a Flocks will be rotated between seasonal soft release enclosures at differing locations each year, conditioning nomadic behaviors for restoring the ecological function of the species in the wild.

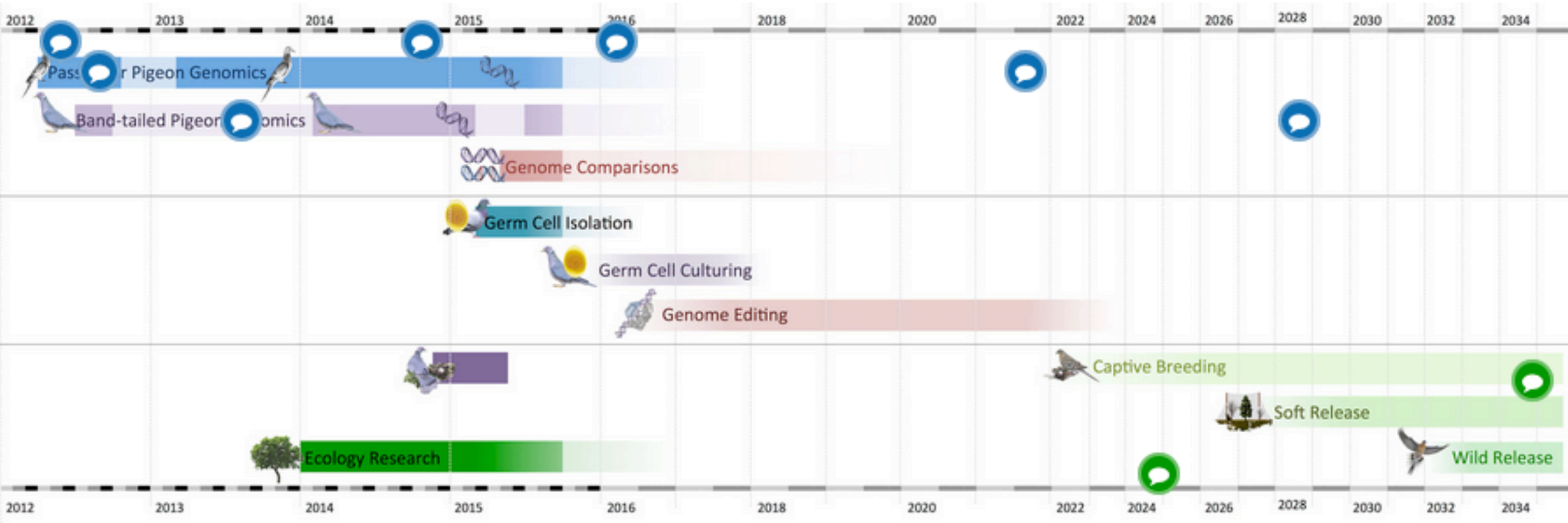




b Free roaming Passenger Pigeons will be monitored to ensure the flocks are moving, breeding, and living the same way that historic flocks did. Numbers will be augmented until flocks are self-sustaining.

http://reviverestore.org/about-the-passenger-pigeon/

Plan and deliver by c. 2035



http://reviverestore.org/about-the-passenger-pigeon/

BRINGING BIOTECHNOLOGIES TO CONSERVATION

THE REVIVE & RESTORE MISSION IS TO ENHANCE BIODIVERSITY THROUGH THE GENETIC RESCUE OF EXTINCT AND ENDANGERED SPECIES.

Ecosystems around the world face unparalleled biodiversity loss. But solutions are available. Genomic technologies have evolved and are increasingly affordable and dynamic. This presents an opportunity to address conservation challenges in ways never before possible. We can rewrite the story of species decline with a new Genetic Rescue Toolkit. This conservation toolkit includes a wide variety of biotech applications—from genomic sequencing and biobanking, to advanced reproductive technologies and gene editing—all insightful, powerful tools that will address some of the planet's most pressing problems.

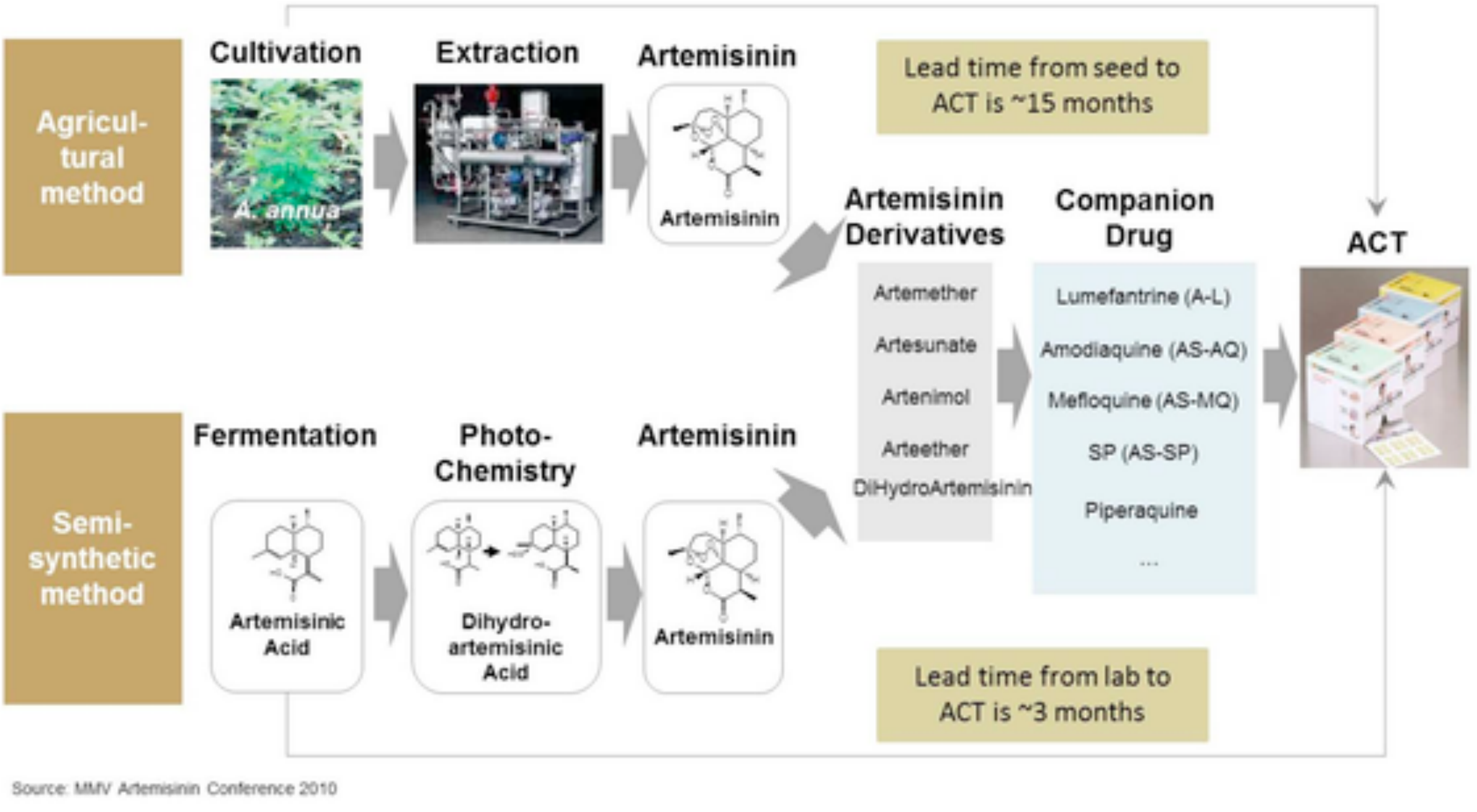
Learn More About Genetic Rescue

OCEAN GENOMICS HORIZON SCAN

CORAL CLIMATE CHANGE RESILIENCE

CATALYST SCIENCE FUND

“Simpler” example — change land use by brewing medicines in place of farming traditional plants…



http://patentsforhumanity.devpost.com/submissions/10871-semi-synthetic-artemisinin-for-treating-malaria

"Glucose can be produced in various ways: maize, sugar cane, potatoes..

“It seems that two average size potato farms in Idaho (supporting say 100 seasonal workers between them with only very part-time employment) could theoretically replace approximately 100,000 growers in the global artemisinin trade.”

For natural artemisinin:

2 MT per ha dry leaf with lets say 1% content and 75% industrial efficiency yields a number of 15 kg of artemisinin. For one MT this means close to 67 hectares per MT of artemisinin.

so for the whole 200 MT artemisinin market around 13 000 ha for Natural artemisinin closer to 25 000 in actual Chinese conditions.

There is 35 times more land use with natural compared to SSA

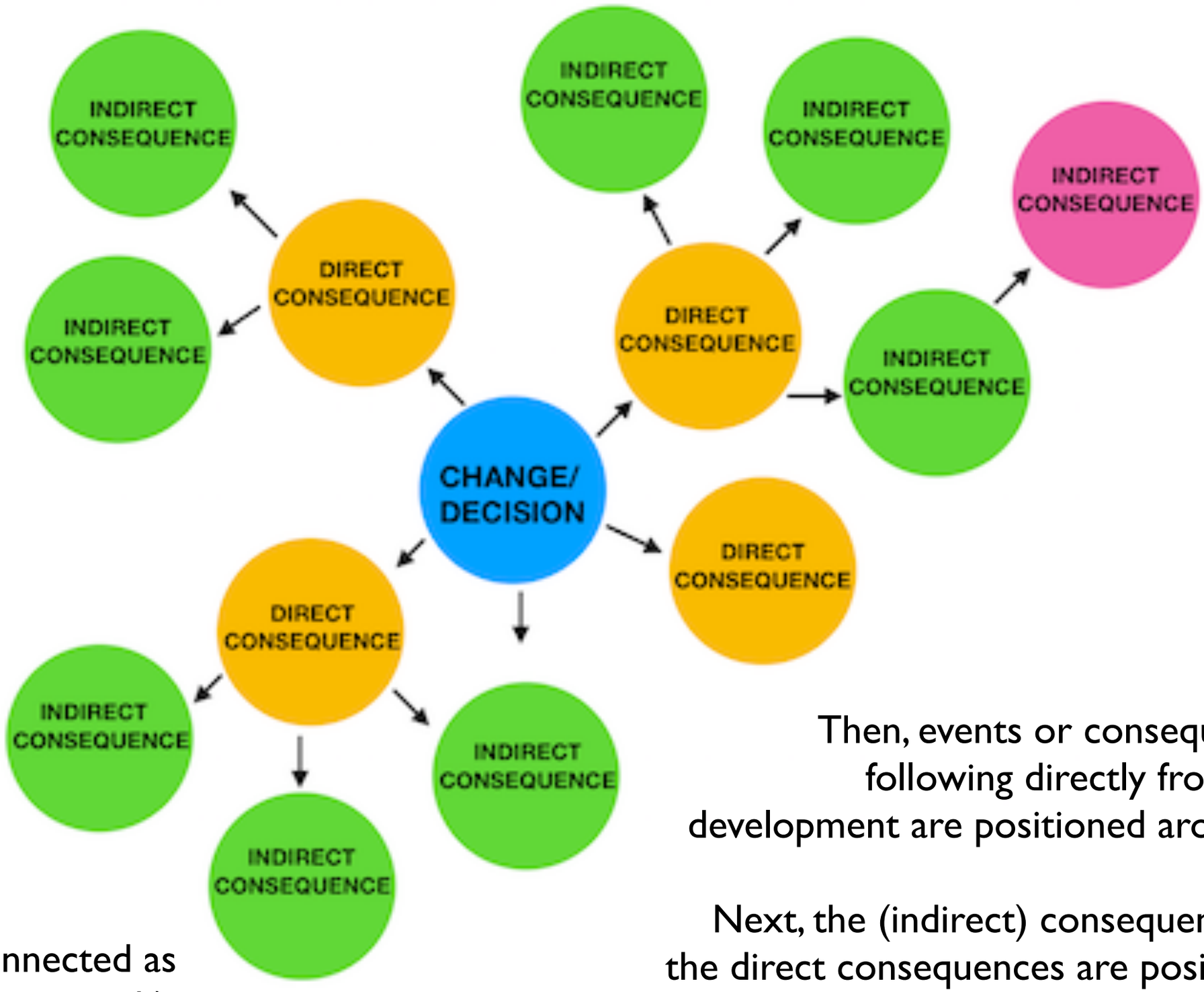
It would be too simple and naive to consider that the issue is a debate of land use for food crop versus a cash crop such as artemisia annua. Most often this is not the case."

personal communication, Jim Thomas, ETC Group

FUTURES WHEEL

The futures wheel is a method for graphical visualization of direct and indirect future consequences of a particular change or development.

To start a futures wheel the central term describing the change to evaluate is positioned in the center of the page (or drawing area).



Then, events or consequences following directly from that development are positioned around it.

Next, the (indirect) consequences of the direct consequences are positioned around the first level consequences.

The terms may be connected as nodes in a tree (or even a web).

https://study.com/academy/lesson/decision-making-wheels-definition-use-in-managerial-decision-making.html

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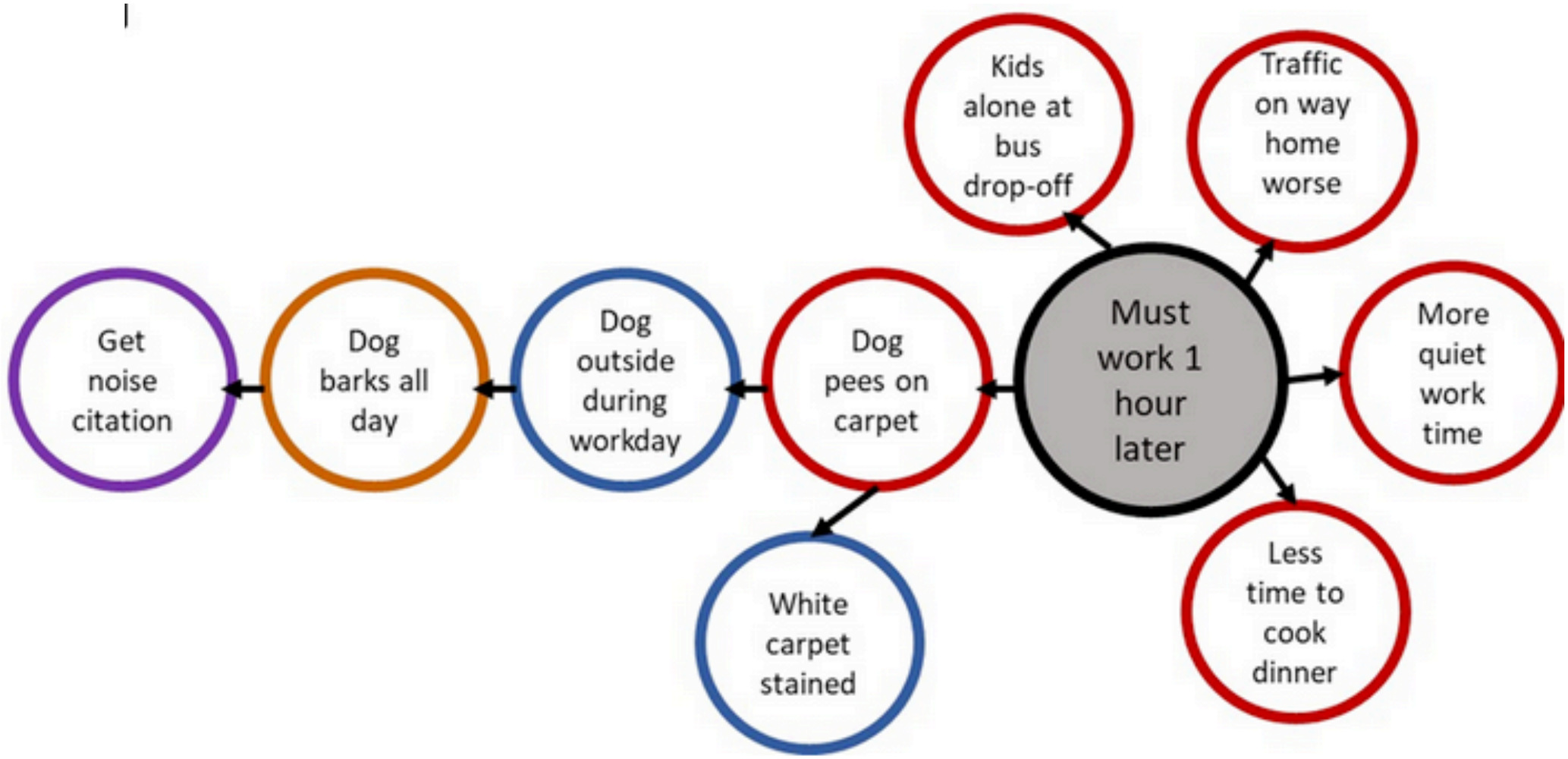

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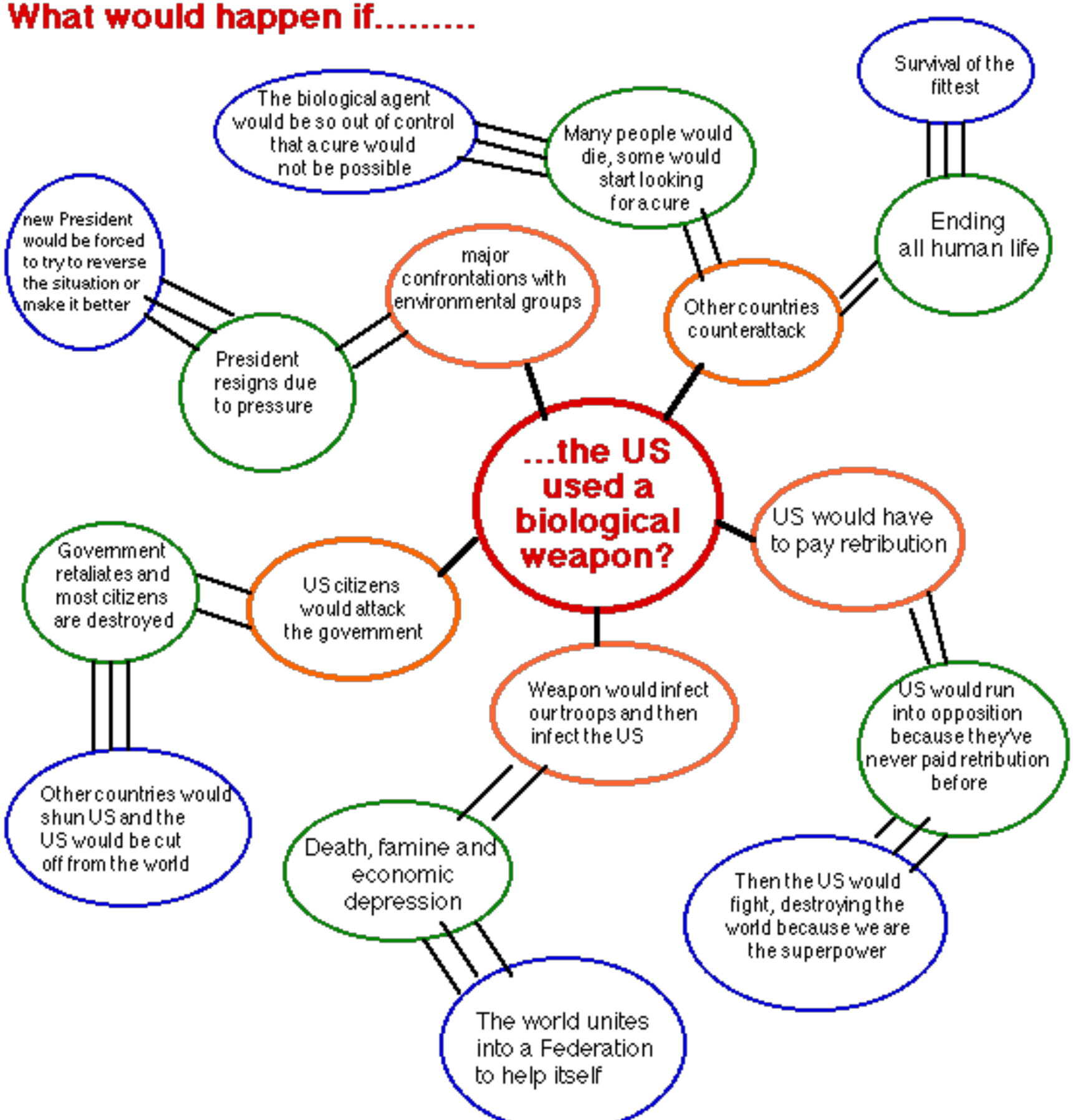
https://novelnarrative.blog/cause-and-effect/

What would happen if.....



https://www.google.com/imgres?imgurl=http%3A%2F%2Fwww.framtidsbygget.se%2FE%2Ftrendanalys%2Fimg%2Ffutures_wheel.gif&imgrefurl=http%3A%2F%2Fwww.framtidsbygget.se%2FE%2Ftrendanalys%2F&tbnid=6Fuxpa-xtiNBbM&vet=12ahUKEwic_bO5mevoAhUyAzQIHSCmBo4QMygOegUIARD4AQ..i&docid=wCsCICsNFRv9HM&w=500&h=375&q=futures%20wheel%20examples&hl=en&ved=2ahUKEwic_bO5mevoAhUyAzQIHSCmBo4QMygOegUIARD4AQ#h=375&imgdii=Mwn3cFED0qxG1M:&vet=12ahUKEwic_bO5mevoAhUyAzQIHSCmBo4QMygOegUIARD4AQ..i&w=500

BREAKOUT FUTURES WHEEL

Home Brewing
All Medicines

1. Most important planet-health impact?
2. Most surprising indirect impact?