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GRADE 12 PRELIMINARY EXAMINATION

LIFE SCIENCES: PAPER II

SEPTEMBER 2023

SOURCE MATERIAL BOOKLET FOR QUESTIONS 1, 2 AND 3
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SECTION A**QUESTION 1**

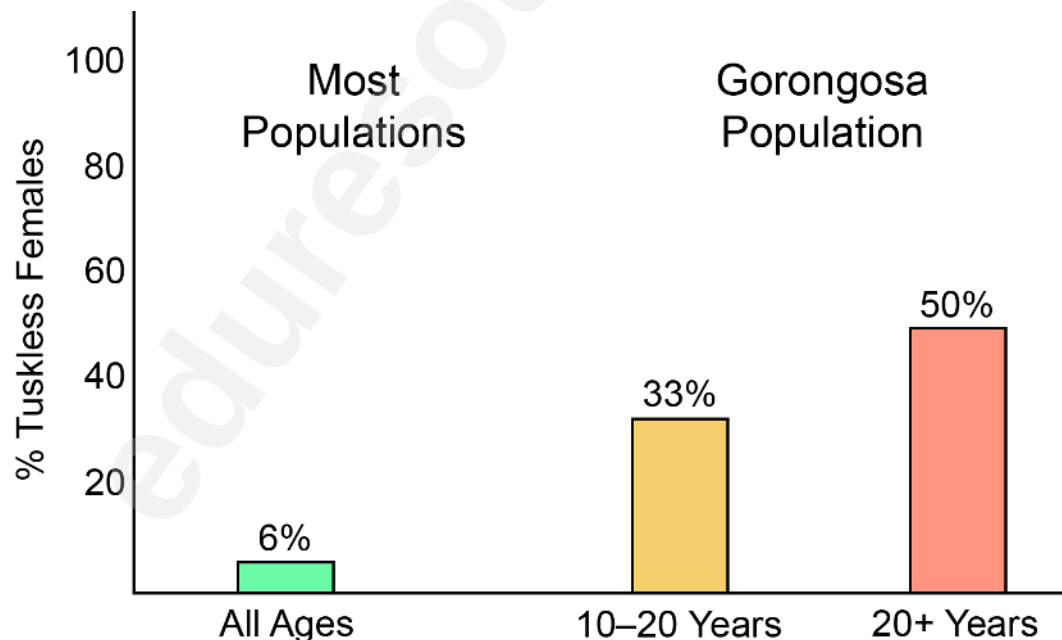
Read the information below. Refer to this information, as well as your own knowledge to answer Question 1 on the question paper.

Source A**Tuskless Elephants of the Gorongosa National Park, Mozambique**

Most African elephants have tusks, but some, about 2% to 6% of females and even fewer males, never grow them. Elephant tusks are important for obtaining food and water, and essential to male elephants for competing for mates, so one might expect strong natural selection for having tusks. But the proportion of tuskless elephants has increased in some populations.

Now researchers have pinpointed how years of civil war and poaching in Mozambique have led to a greater proportion of elephants that will never develop tusks.

During the conflict from 1977 to 1992, fighters on both sides slaughtered elephants for ivory to finance war efforts. In the region that's now Gorongosa National Park, around 90% of the elephants were killed. After the war, those tuskless surviving females passed on their genes with expected, as well as surprising, results. Among the older female elephants that survived a period of heavy poaching in the park, over 50% are tuskless. Among the younger females, who were born after this period of heavy poaching, 33% are tuskless.



Most African elephants have tusks, but typically about 6% of females in a population will never grow tusks. Adult males are very rarely found without tusks. However, in Gorongosa National Park in Mozambique, 50% of females over 20 years old are tuskless, and 33% of females between 10 and 20 years old are tuskless.

Source A continued

In Gorongosa, the team collected blood samples from seven tusked and 11 tuskless female elephants, then analyzed their DNA for differences.

The elephant survey data gave them an idea where to look: Because the tuskless elephants were female, they focused on the X chromosome. (Females have two X chromosomes; males have one X and one Y chromosome.)

They also suspected that the relevant gene was dominant – meaning that a female needs only one altered gene to become tuskless — and that when passed to male embryos, it may “short-circuit their development”.

“When mothers pass it on, we think the sons likely die early in development, a miscarriage,” said Brian Arnold, a co-author and evolutionary biologist at Princeton.

The years of unrest “changed the trajectory of evolution in that population,” said evolutionary biologist Shane Campbell-Staton, based at Princeton University.

Most people think of evolution as something that proceeds slowly, but humans can hit the accelerator. “The fact that this dramatic selection for tusklessness happened over 15 years is one of the most astonishing findings.” said Samuel Wasser, a conservation biologist at the University of Washington.



This undated photo provided by ElephantVoices in October 2021 shows tuskless elephant matriarch with her two calves in the Gorongosa National Park in Mozambique.

Adapted: <https://www.biointeractive.org/planning-tools/science-news/why-no-tusks-poaching-tips-scales-elephant-evolution>

Source B

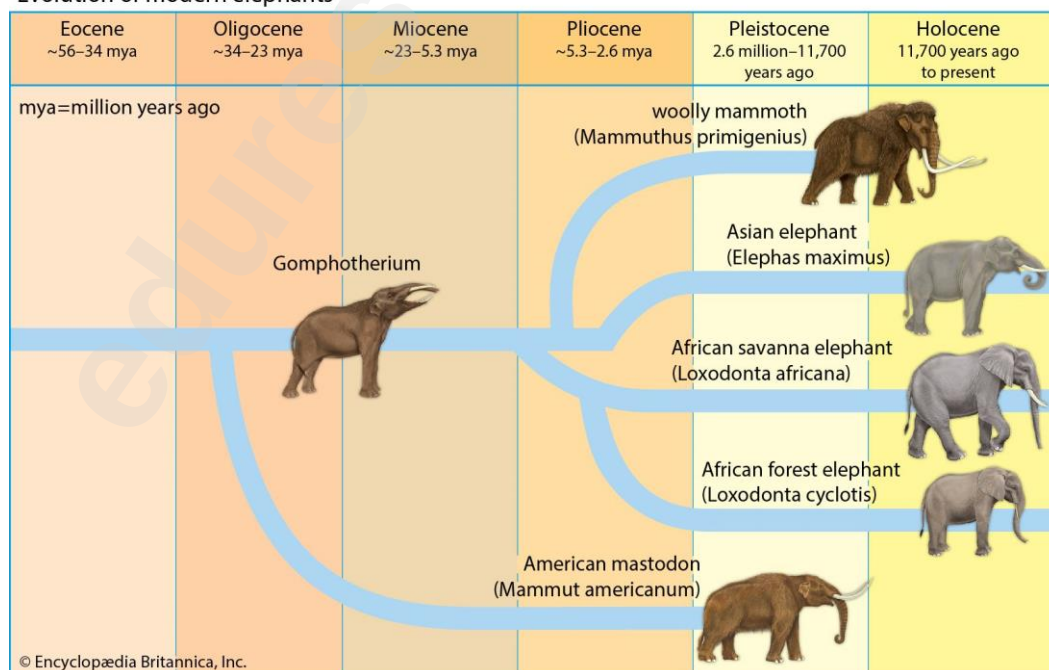
Tusklessness *seemed* like selection in action, but researchers needed more evidence. One of their tests checked to see if the change observed in the elephant population could have been caused by chance, instead of by natural selection. When populations get small (as happened to the Gorongosa elephant population during the civil war), it's easy for some gene variants to be over- or under- represented from one generation to the next just by chance alone (i.e., through a population bottleneck and genetic drift). Was tusklessness actually helpful for survival or did it become more common just by chance when so many elephants were killed?

To find out, the researchers ran simulations (i.e., a model) to see how a population of 2542 elephants, of which 18.5% of females were tuskless (the situation in 1972), was likely to evolve over 28 years if tuskless and tusked elephants were equally likely to survive. They set up the model so that the population decreased to just 242 individuals (the situation in the year 2000). The simulation predicted that the population would almost always end up with less than 30% tuskless females if tusked and tuskless elephants had the same chances of survival. But in actuality, the researchers had found that over half the female elephants in Gorongosa were tuskless in the year 2000. This and several other lines of evidence convinced the team that their hypothesis was correct: natural selection favoring tuskless elephants was to blame for the shift towards tusklessness.

Adapted: <https://evolution.berkeley.edu/evo-news/the-evolution-of-tuskless-elephants-foils-poachers-but-at-a-cost>

Source C

Evolution of modern elephants



<https://www.britannica.com/animal/elephant-mammal>

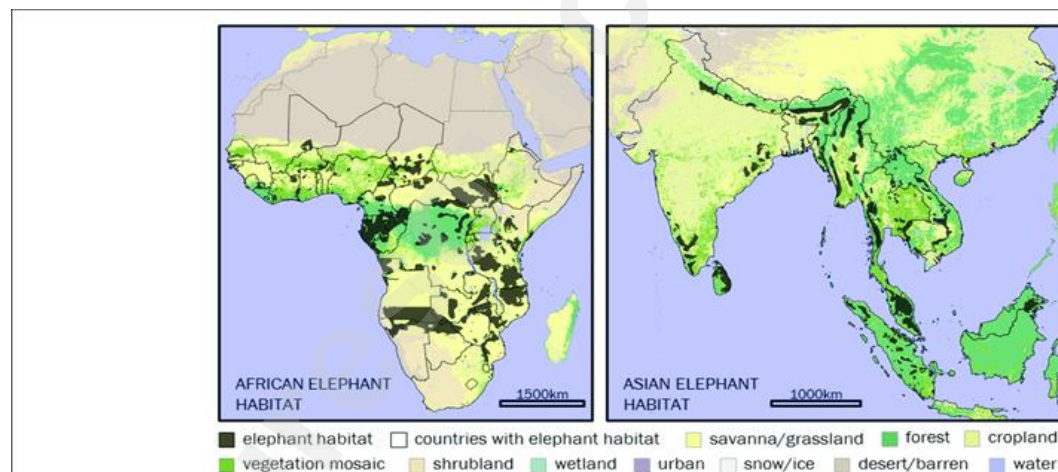
Source D

Distribution of elephants globally

By comparing the DNA of modern elephants from Africa and Asia to DNA extracted from two extinct species, the woolly mammoth and the mastodon, researchers have concluded that Africa has two -- not one -- species of elephant. Since 1950, all African elephants have been conserved as one species. Now that we know the forest and savanna elephants are two very different animals, the forest elephant should become a bigger priority for conservation purposes.

Previously, many naturalists believed that African savanna elephants and African forest elephants were two populations of the same species, despite the significant size differences. The savanna elephant has an average shoulder height of 3.5 meters whereas the forest elephant has an average shoulder height of 2.5 meters. The savanna elephant weighs between six and seven tons, roughly double the weight of the forest elephant.

DNA analysis revealed a wide range of genetic diversity within each species. The savanna elephant and woolly mammoth have very low genetic diversity, Asian elephants have medium diversity, and forest elephants have very high diversity. Researchers believe that this is due to varying levels of reproductive competition among males.



<https://www.sciencedaily.com/>

<https://www.researchgate.net/figure/Map-of-global-elephant-species-ranges>

Source E**Reproductive behaviour between elephants**

Male elephants enter a periodic state called 'Musth' when they are ready to mate. It's when the temporal gland, located on the side of the head between the ear and the eye, produces a dark fluid (Temporin) with a strong musky odor. A male elephant generally enters musth once a year, for a period of one month. Musth bulls have heightened levels of testosterone and are very aggressive, especially toward other bulls.

Reproductive receptiveness is often displayed in females by greater interest and enthusiasm at the approach of a musth bull. Receptive females may also exhibit an oestrous walk, characterized by holding their head held high and frequently looking over their shoulders. Oestrous females (reproductively receptive) will also vocalize at this time. These sounds travel long distances and help distant musth bulls locate the female.

Competition for potential mates is settled by bulls through a trial of strength, usually pushing, tusking, wrestling, and ramming. The weaker of the two bulls is forced to retreat and gives up mating rights to the female. Rarely do these mating fights turn brutal, as they are a quick assessment of strength and virility (strong sex drive).

Successive mating occurs briefly from a few hours to four days. Males usually stay with the female after mating to prevent her from mating with other males.

Adapted: <https://seaworld.org/animals/all-about/elephants/reproduction>

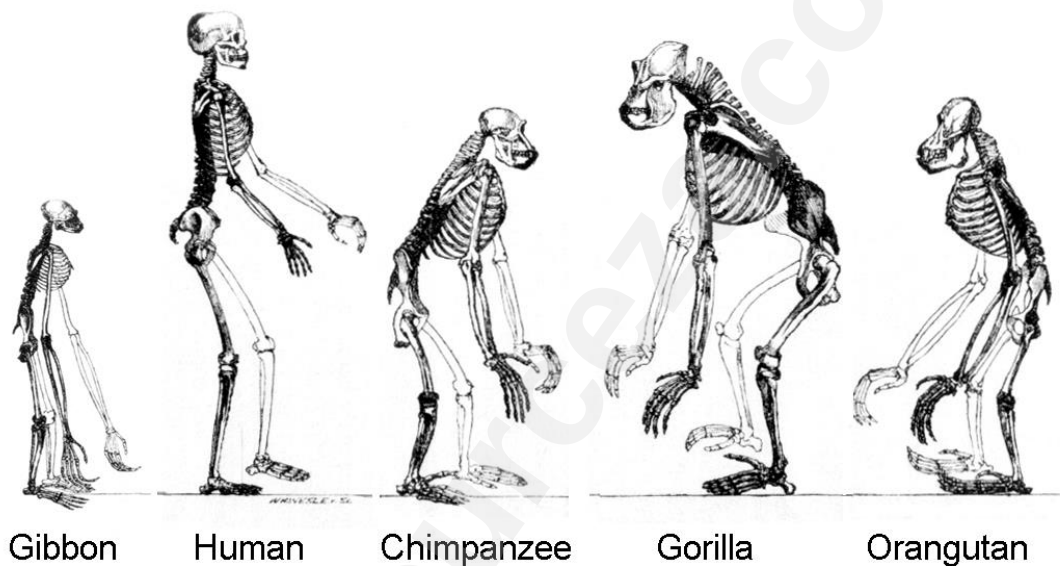
Adapted: <https://jeje-bonita.wixsite.com/animals->

QUESTION 2

Read the information below. Refer to this information, as well as your own knowledge to answer Question 2 on the question paper.

Source A

Primates are a large group of social mammals that arose between 85 Ma and 55 Ma, probably from small tree-dwelling mammals. Shared characteristics of primates include relatively large brains, visual acuity, colour vision, dexterous hands (prehensile with opposable thumbs for grasping), and large ranges of motion in their shoulder joints.



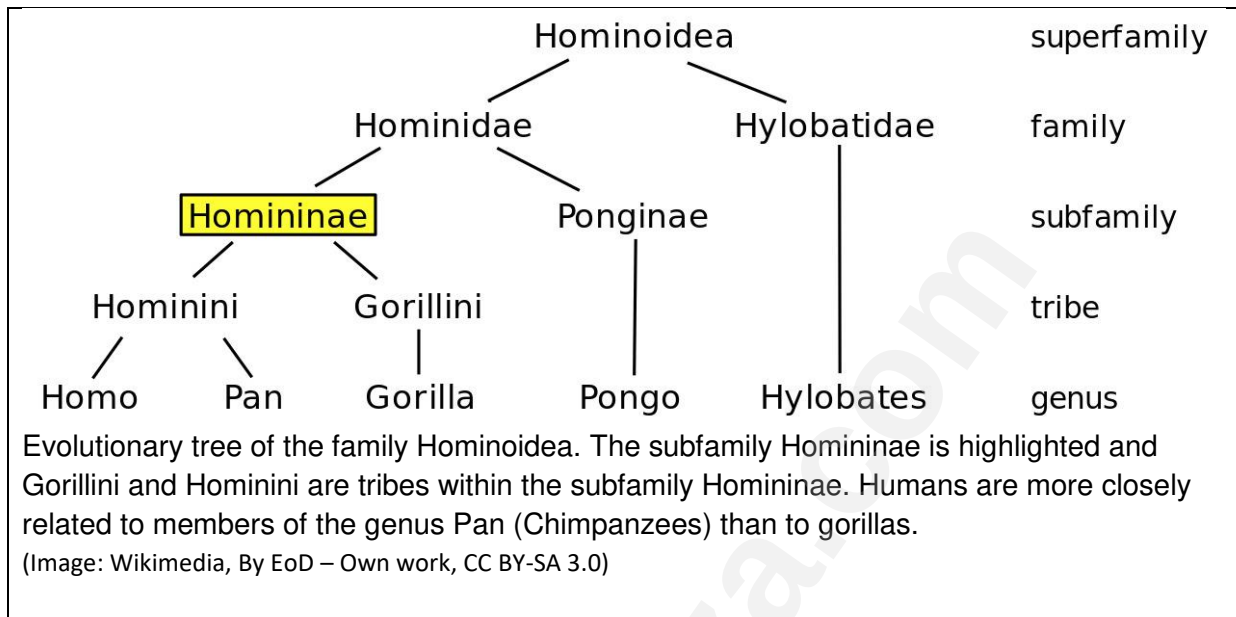
Skeletons of members of the ape superfamily, Hominoidea.

Image: Wikimedia, Public Domain

Hominidae – The **hominids** are the human taxonomic family. It is more colloquially referred to as the “great apes”. The term “hominid” is sometimes also used generally. Within this family, there are currently eight extant (living) species, contained within four genera. These species include us, *Homo sapiens*, Orangutans (*Pongo abelii*, *Pongo tapanuliensis*, *Pongo pygmaeus*), Gorillas (*Gorilla gorilla*, *Gorilla beringei*), and Chimpanzees (*Pan troglodytes*, *Pan paniscus*).

Homininae – The **hominins** are our subfamily and refers specifically to “African Apes”. This subfamily is divided into two “tribes” (the term is no connection to that which is used for indigenous human groups), Hominini and Gorillini.

Source A continued



Adapted : <https://opengeology.org/historicalgeology/case-studies/human-evolution/#Paleoanthropology>

Source B

Hominid Skull Terminology

Below is a summary of some of the major parts of hominid skull anatomy.

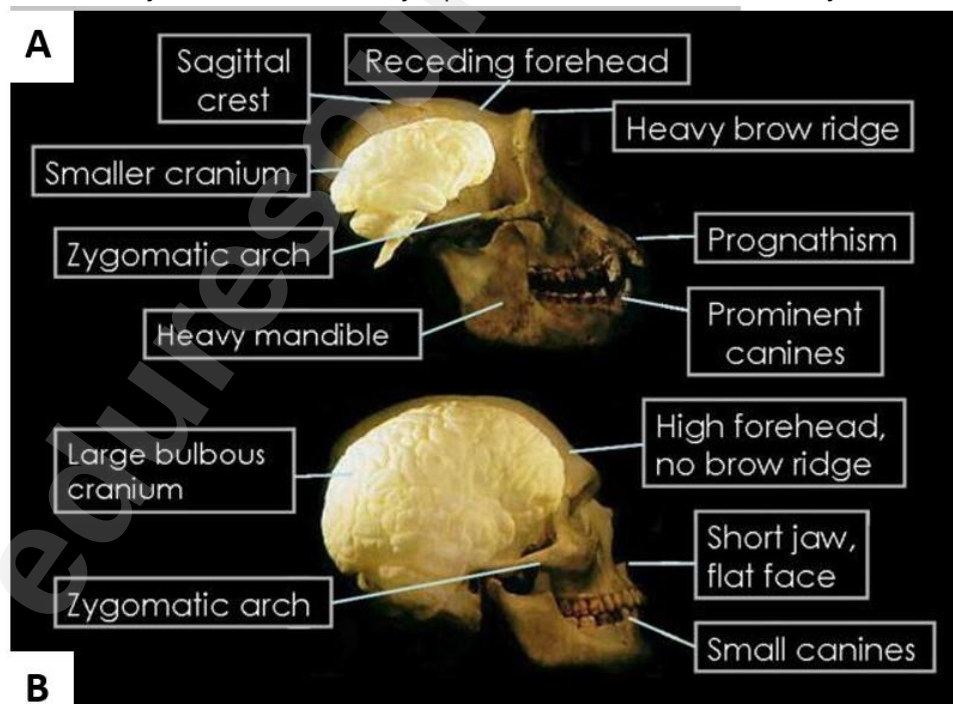


Image: Public Domain

A summary of hominid skull features, comparing Human and Australopithecine skulls.

Other skull features provide support for changes in locomotion, specifically the evolution from walking on all fours to full bipedalism or walking upright on two feet. Today, humans are bipedal.

Source C

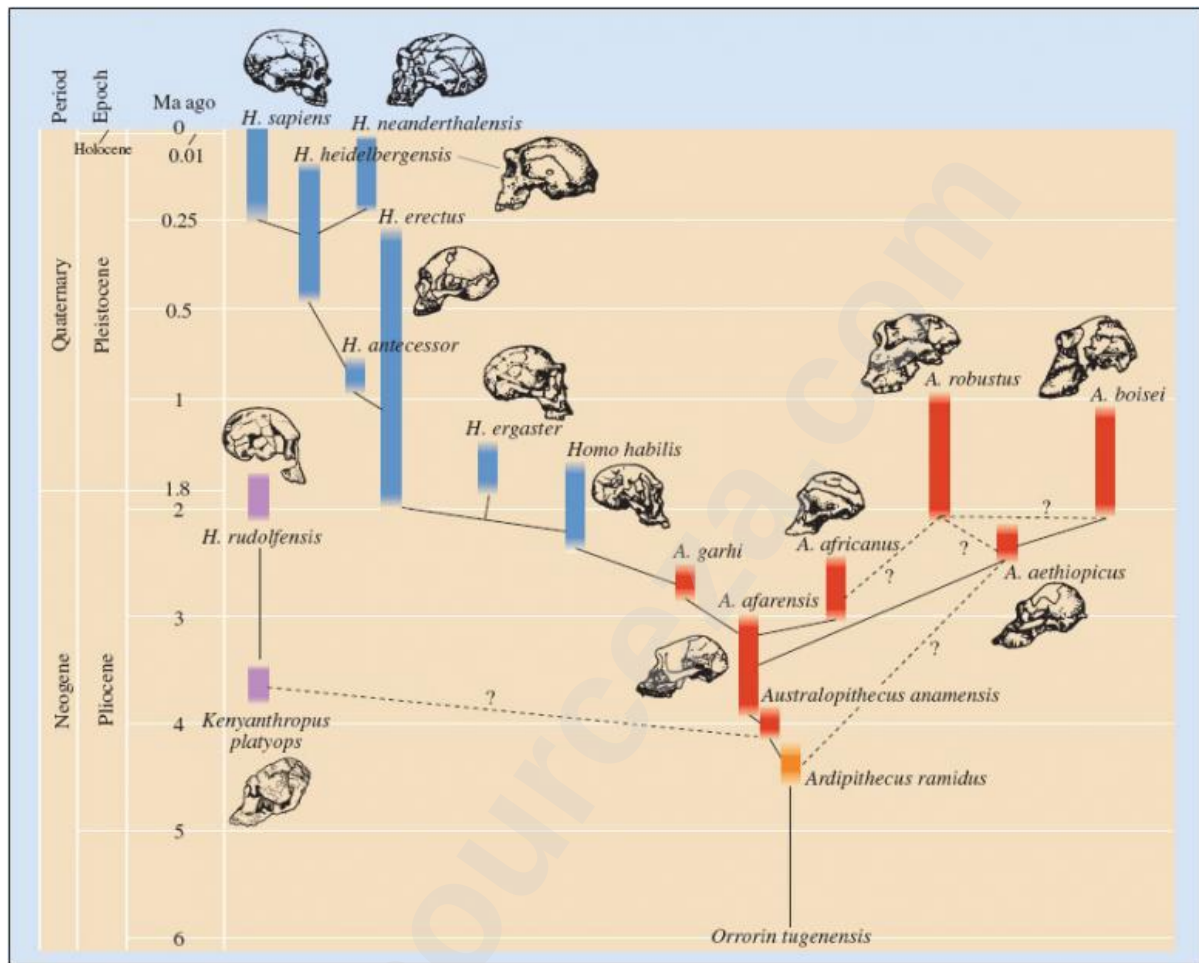
Highlights of our family tree: Australopithecines and *Homo*

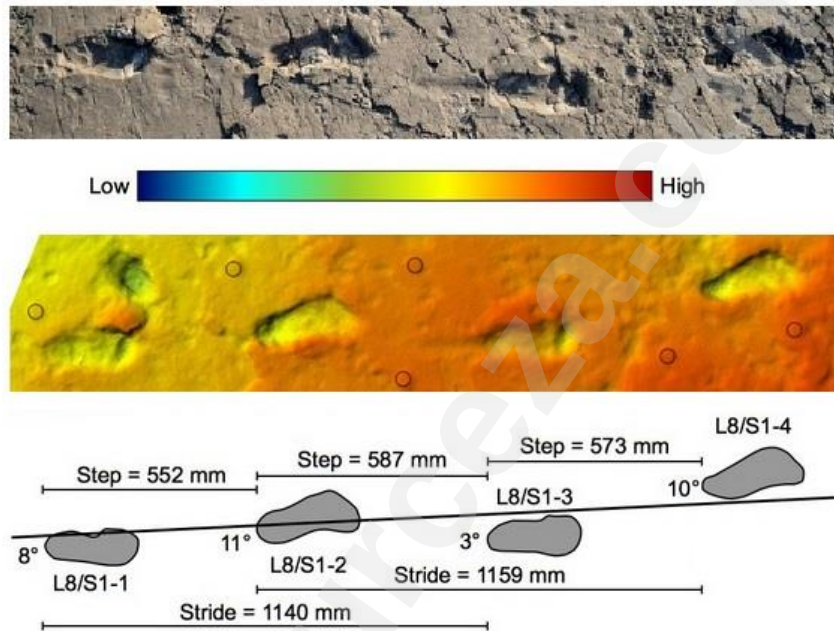
Image: Public Domain

A current tentative arrangement of the ancestral human lineage. The Australopithecines are placed here in context with modern humans in time.

Source D

Bipedalism

There is no doubt that modern humans are primarily bipedal and that our Australopithecine ancestors were not. In between, there is a clear progression from walking on fours to walking on two legs.



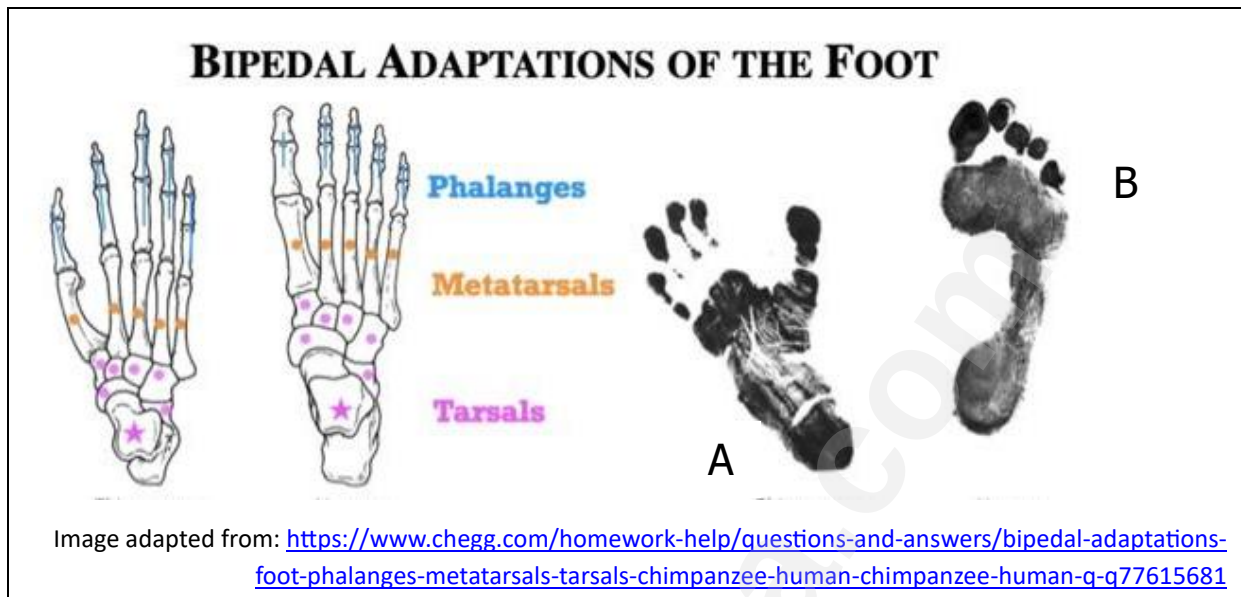
A portion of the Laetoli trackway, preserved in volcanic ash. (Image: Fidelis T Masao Elgidius B Ichumbaki Marco Cherin Angelo Barili Giovanni Boschian Dawid A Iurino Sofia Menconero Jacopo Moggi-Cecchi Giorgio Manzi cropping/editing by Dennis Pietras – parts of 2 figures from <https://elifesciences.org/content/5/e19568> licensed under CC BY 4.0)

The advantages of bipedalism are very important. With the climate changing so drastically in Africa, from tropical rainforests to savannah, being bipedal becomes a survival strategy. It is now possible to see over the grasses.

There are also disadvantages to walking on two legs. The curvature of the lower spine that makes balancing on two legs possible also leads to much more lower back pain, and perhaps most importantly because of its role in reproduction – bipedalism works with a narrow pelvis.

Adapted from: <https://opengeology.org/historicalgeology/case-studies/human-evolution/#Paleoanthropology>

Source D continued

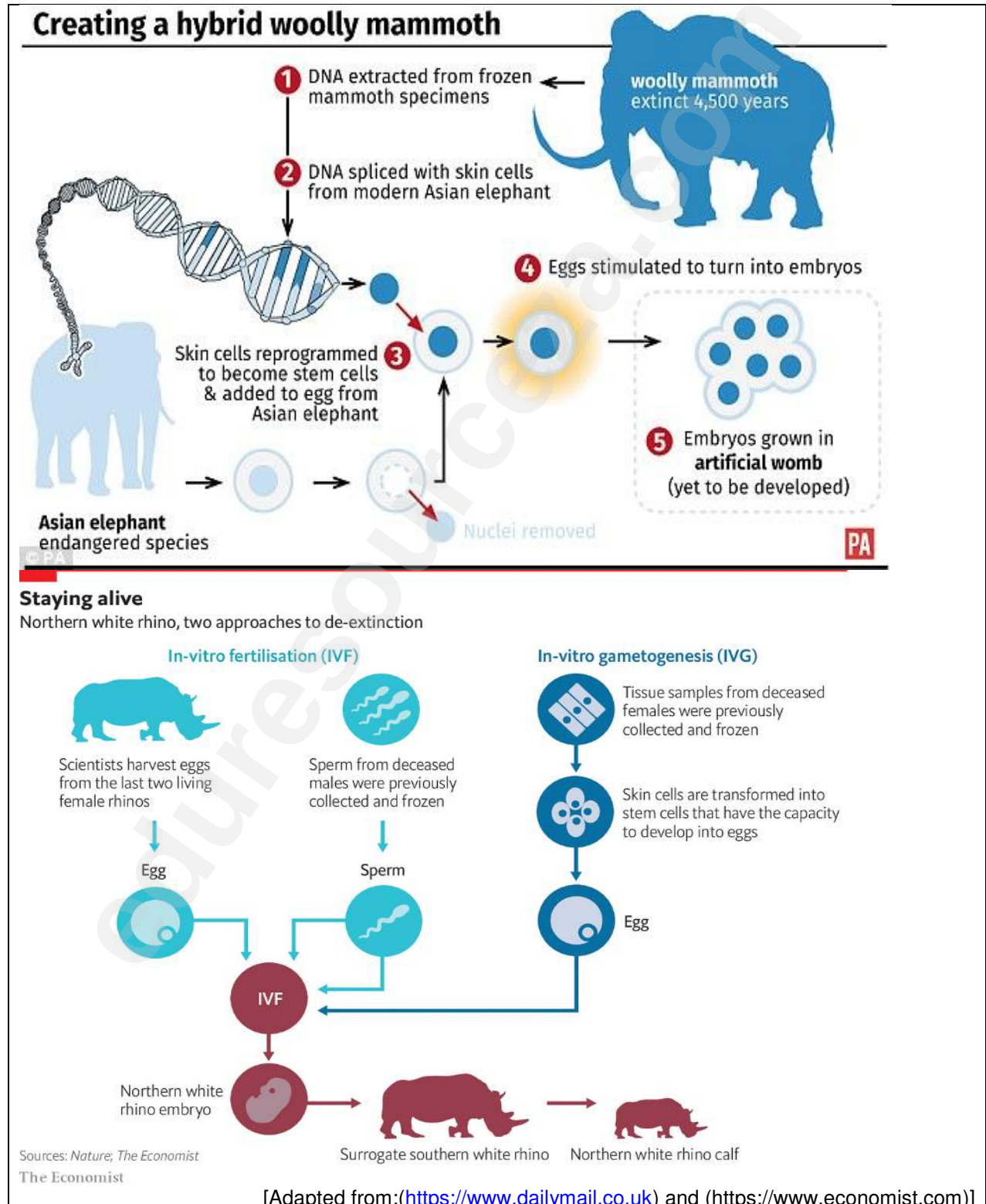


SECTION B

QUESTION 3

Read the information below. Use this information, as well as your own knowledge, to answer Question 3 on the question paper.

SOURCE A The De-extinction process



SOURCE B De-extinction of Mammoths

By Karen Grimaldos

[DECEMBER 6, 2021](#)

As You Read, Think About: How might bringing back extinct creatures help other animals?

Woolly mammoths were huge, elephant-like creatures that became extinct nearly 10 000 years ago.

A company called Colossal plans to bring woolly mammoths back from extinction within the next few years. Colossal will use a process called de-extinction. They'll take DNA from a frozen mammoth. Scientists will copy the DNA into the cells of the mammoth's closest living relative, the Asian elephant. Some people think it would be exciting to see prehistoric creatures roam the planet again. But many scientists are concerned that de-extinction could cause more harm than good.

Many experts believe bringing back mammoths would be one of the greatest conservation victories of all time. Mammoths were a keystone species in the Arctic meaning they had a major impact on their ecosystem. The Colossal team says reintroducing mammoths could greatly boost biodiversity.

Colossal also aims to prevent climate change. Mammoths scraped away snow, allowing air to reach the frozen soil beneath, called permafrost. Without the beasts, snow blanketed the permafrost, which warmed. That released greenhouse gases and warmed the Arctic. Some scientists say bringing back mammoths can reverse that.

Supporters of de-extinction say the process could also save endangered species. They argue that the technology could be used to change the DNA of other animals to make them stronger and better able to fight diseases. Eriona Hysolli is the head biologist at Colossal. She believes her team's efforts could protect animals in danger of disappearing.

Scientists point out that the new creature won't actually be a woolly mammoth—it will be a mix of mammoth and elephant. Some say creating a hybrid like this is a cruel experiment. Many worry the new animals could suffer from serious health problems and will be subject to constant testing. They fear the new species might not survive.

[Adapted: (<https://sn4.scholastic.com/pages/promotion/navigationlps/120621/should-we-bring-back-extinct-animals.html>)]

SOURCE C

7 Animal extinctions in the last century

7 Animals That Have Gone Extinct In The Past 100 YearsWritten by Rebecca Mathews (Professional Researcher)

Updated: May 12, 2023



The **Japanese sea lion**, *Zalophus japonicus*, was an aquatic mammal that lived in the Sea of Japan, the Korean Peninsula, and the Japanese archipelago. They were hunted to extinction in the 1900s for their fat and oils. Their internal organs were used in medicine, and even their whiskers were used to clean pipes.

Golden toads (*Incilius periglenes*) were endemic to Monteverde Cloud Forest Reserve, a four km² of high-altitude land in Monteverde, Costa Rica. This little toad was only discovered in 1964, but by 1989 they couldn't be found. The species has been declared extinct, and experts aren't sure what happened. Their limited range was a problem because of a severe drought in the 1980s. Climate change and a possible disease may also have contributed to their decline.

The most recent animal that has gone extinct in the past 100 years is the **West African Black Rhinoceros** (*Diceros bicornis longipes*). West African Black Rhinos were hunted to extinction because their horns were valuable in herbal medicine. Intensive poaching plummeted the species from over a million in the 1960s to a few thousand by 1995. A governmental campaign tried to save them, but it was too late. The last one was seen in Cameroon's northern province in 2006. They were declared extinct in 2011.

The **Chinese river dolphin**, *Lipotes vexillifer*, is better known as the baiji. It hasn't been seen since 2002, but it was once numerous in China's Yangtze River. In the early 1900s, they were extensively hunted, then in the 1950s, net fishing became industrialized, and hydroelectricity dams changed their habitats. Officials have searched for years, but since 2002 baiji haven't been seen. Although Chinese river dolphins are listed as critically endangered, experts think they are extinct.

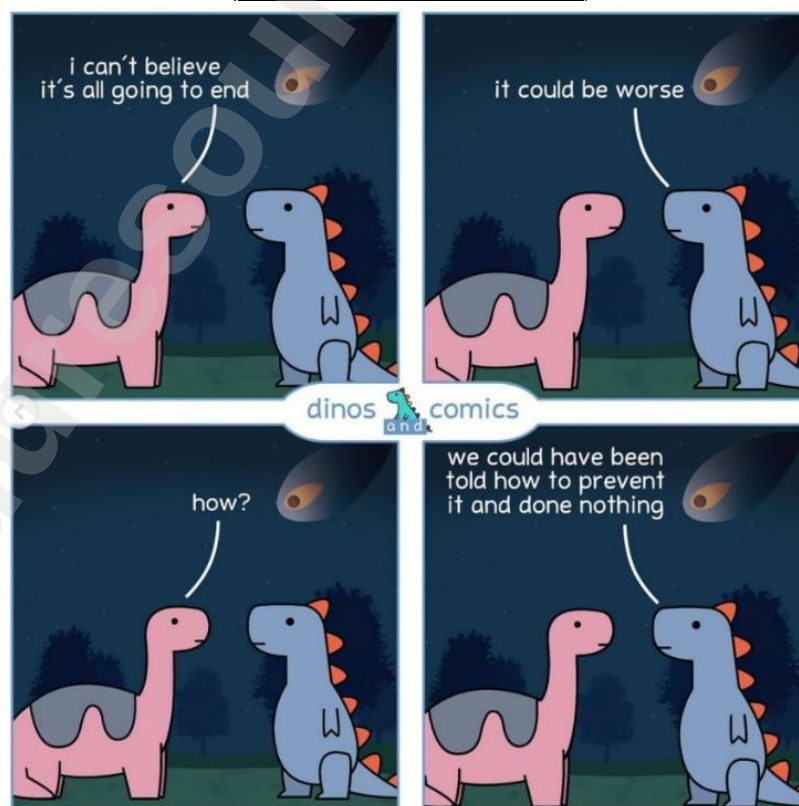
[Adapted: (<https://a-z-animals.com/blog/animals-that-have-gone-extinct-in-the-past/>)]

SOURCE D

Cartoons



(<https://www.boredpanda.com>)



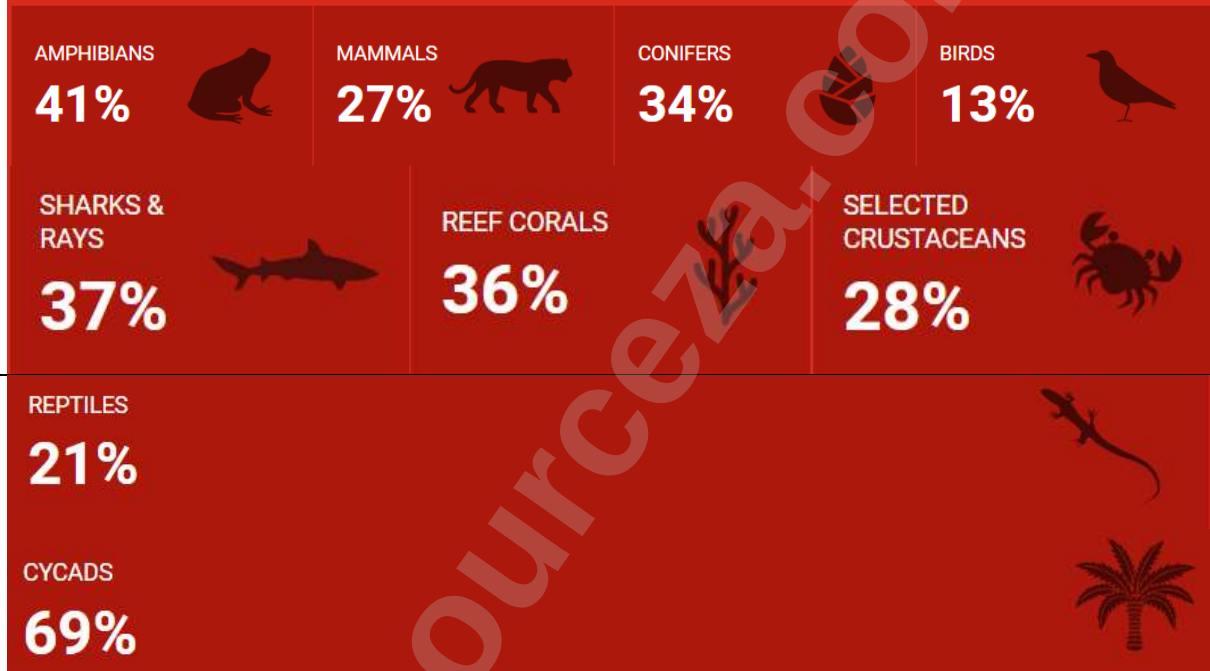
(<https://dinosaurcouch.com>)

SOURCE E

Statistics

More than 42,100 species are threatened with extinction

That is still 28% of all assessed species.



International Union for Conservation of Nature and Natural Resources. Updated 2022.

[Adapted (<https://www.iucnredlist.org/>)]

IUCN Data for South Africa (updated December 2022)

Chordate class	Number of endemic species	Number of threatened species	Number of extinct species
Mammals	41	15	1
Birds	18	6	0
Reptiles	137	19	2
Amphibians	60	16	0

According to the IUCN red list, in 2022 a total of 9 251 of the Earth's species are listed as critically endangered and 16 364 species are endangered.

[Adapted (<https://www.iucnredlist.org/>)]

SOURCE F

The Dearly Departed Dodo

A de-extinction company known for its plans to resurrect the mammoth and Tasmanian tiger has announced it will also bring back the dodo

Christine Kenneally

on January 31, 2023

Colossal Biosciences, the headline-grabbing, venture-capital-funded juggernaut of de-extinction science, announced plans on January 31 to bring back the dodo. Whether “bringing back” a semblance of the extinct flightless bird is feasible is a matter of debate.

Founded in 2021 by tech entrepreneur Ben Lamm and Harvard University geneticist George Church, the company first said it would re-create the mammoth. And a year later it announced such an effort for the thylacine, aka the Tasmanian tiger. Now, with the launch of a new Avian Genomics Group and a reported \$150 million of additional investment, the long-gone dodo joins the line-up.

“This announcement is really just the start of this project,” says Beth Shapiro, lead palaeogeneticist and a scientific advisory board member at Colossal Biosciences. Shapiro, also a professor of ecology and evolutionary biology at the University of California, Santa Cruz, has studied the dodo since the science of palaeogenetics was in its infancy. In 2002 she published research in *Science* describing how her team had extracted a tiny piece of the bird’s mitochondrial DNA (mtDNA)—the DNA inside little organelles called mitochondria that gets passed down from mother to offspring. That snippet of mtDNA showed the dodo’s closest living relative was the Nicobar pigeon. Then, in 2022, Shapiro announced that her team at U.C. Santa Cruz had reconstructed the dodo’s entire genome.

Most de-extinction programs aim to re-create a proxy (animals close enough to carry out the same function in the extinct species’ old ecosystem) of an extinct animal by genetic engineering, editing the genome of a closely related living species to replicate the target species’ genome. The edited genome would then be implanted into an egg cell of that related species to develop. The process must ensure that development proceeds correctly, that the animal is born successfully, that suitable surrogate parents nurture the creature, that it is administered a nutritious diet and that it is raised in an appropriate environment.

One of the biggest challenges in the reconstruction of the dodo is a problem for all avian genomics. With mammals, the process is like that used in the creation of Dolly the sheep, the world’s first animal to be cloned successfully from adult cells. But, Shapiro says, “we can’t clone birds.” Cloning requires access to an egg cell that is ready for fertilization but not yet fertilized. “There is no access to a bird egg cell at the same developmental time as there is for a mammal,” she explains. Colossal Biosciences is exploring a process to extract avian primordial germ cells (PGCs) from bird eggs. If the process works, PGCs from pigeons would be manipulated to eventually develop into a dodolike bird.

Beyond behaviour, the dodo proxy must survive in a world that is significantly different from that of more than 300 years ago, when the dodo went extinct. Yet not much is known about how dodos functioned in their ecosystem. The birds lived only in forests on Mauritius. They had no large predators. They were slow to reproduce, laying one egg per year.

“If we are going to bring back something that’s functionally equivalent to a dodo, then we will have to find, identify or create habitats in which they’re able to survive.” Shapiro points to environmental restoration on Mauritius and surrounding islands. There is hope that work focused on dodo habitat restoration could have knock-on benefits for other endemic plants and animals and even that the reintroduced bird may directly contribute to restoring its own ecosystem. Giant tortoises introduced to an island near Mauritius to replace an extinct species have helped revive native ebony trees by eating their fruit and distributing their seeds around the landscape.

The de-extinction of the dodo is “not a solution to the extinction crisis,” Shapiro says. “Extinction is forever.” But by pursuing the problem of dodo de-extinction, she explains, Colossal Biosciences is also developing critically needed tools for avian genomics, including for the genetic rescue of currently threatened species, such as editing genetic diversity back into a shrunken, threatened bird population. In this way, a 21st-century dodo may assist all avian conservation

The dodo is only one of many lost birds: 161 avian species have been classified as extinct since 1500, according to a 2017 report from BirdLife International. But Colossal Biosciences is relying on the creature’s significance to inspire scientists and the general public to engage with all the problems of extinction. “We could have picked lots of different birds,” says Shapiro, raising her right arm to reveal a dodo tattoo. “I happen to really love the dodo.”



[Adapted: (<https://www.scientificamerican.com/>)]

SOURCE G

Pros and Cons of De-extinction

How Will De-extinction Help?

- If we are able to resurrect species that have become extinct, especially the keystone species, we will also be able to revive ecosystems that have either been damaged or have disappeared. We will be able to use some of these species as flagship species to protect entire ecosystems. Simply put, de-extinction is the need of the hour, if we are to save the fast-depleting environment.
- It will be a breakthrough in the field of genetic engineering. We will be able to understand what made these species vulnerable to extinction in the first place, and use the information to save related living species. We will also be able to eradicate diseases that are caused by specific genes by introducing immune species in the wild.
- Most of our knowledge about evolution is based on theories. If we are able to bring back extinct species, we could get an insight into the evolution process.
- On the morality front, we humans have been responsible for the extinction of a large number of species, including the Tasmanian tiger and Pyrenean ibex. If we are able to bring them back, it will help us undo the harm we have caused over the years—redemption of sorts.
- And lastly, it will be worth the effort considering that we will be able to see these species, about whom we have only heard, roam the planet.

The question we need to ask is, whether we should bring back species from extinction just because we can; especially when there is a reason why they became extinct in the first place.

[Adapted:(<https://biologywise.com/pros-cons-of-de-extinction>)]

In *Science* today, two Stanford researchers tackle this tricky topic to explain exactly what we have to gain and lose from de-extinction technologies. There are three main ways of bringing back extinct species, according to the Stanford researchers: backbreeding, genetic engineering, and cloning. Based on the current state of the science, the Stanford researchers distill de-extinction down to the pros listed above and the following cons:

Objections to De-Extinction:

- Animal welfare: People could be exploiting animals for solely human purposes, and may cause individuals of the de-extinct species harm.
- Health: Species could carry retroviruses or pathogens when brought back to life.

If an extinct animal were brought back to life in the lab, the authors point out that it would still lack many of a species' key characteristics, such as epigenetics, environment and social groups. Plus it would bring along with it a number of complicated legalities relating to the Endangered Species Act and patent laws.

[Adapted:(<https://www.discovermagazine.com/planet-earth/>)]

SOURCE H

The Christmas Island Rat

Bringing back extinct species may be more difficult than previously thought**By: Elizabeth Pennisi****9 March 2022**

So far, scientists have sequenced the genomes of about 20 extinct species, including a cave bear, passenger pigeon, and several types of mammoths and moas. But no one has yet reported re-creating the extinct genome in a living relative. In the new study, Tom Gilbert, an evolutionary geneticist at the University of Copenhagen, thought it best to start small. So, he, Jian-Qing Lin, a molecular biologist at Shantou University, and their colleagues, focused on the Christmas Island rat (*Rattus macleari*), which disappeared by 1908 from that island, located about 1200 km west of Australia. This species shares a close relationship with the Norway rat, a well-studied lab animal with a complete genome sequence that scientists already know how to modify.

Gilbert and Lin extracted DNA from the skins of two preserved Christmas Island rats and sequenced it many times over to get as much of the genome as possible. They achieved more than 60 times' coverage of it. Old DNA only survives in small fragments, so the team used the genome of the Norway rat as a reference to piece together as much as possible of the vanished rat's genome. Comparing the two genomes revealed almost 5% of the Christmas Island rat's genome was still missing, Lin, Gilbert, and their colleagues report today in *Current Biology*. The lost sequences included bits of about 2500 of the rat's estimated 34,000 genes. The recovered DNA included the genes for the Christmas Island rat's characteristic rounded ears, for example, but important immune system and olfaction genes were either missing or incomplete.

Many of the missing genes will be the ones that make each species unique, Herridge says. She notes that the more time that has passed since an extinct species and its living relative have diverged, the more genes are likely to be missing; the Christmas and Norway rats split 2.6 million years ago, a blink of an eye in evolutionary time; mammoths and the Asian elephants diverged 6 million years ago. "A lot of the talk has made [de-extinction] seem very straightforward, but of course, it's not," Herridge says.

McCauley agrees. He says 5% is a big difference—the human genome differs by just 1% from those of chimps and bonobos. "We could make something, but it seems clear it will never be a Christmas Island rat," he adds. "In which case, what is the point?"

But Andrew Pask, a developmental biologist at the University of Melbourne, Parkville, who is spearheading an effort to bring back an extinct marsupial called the thylacine, or Tasmanian tiger, is unfazed by the new report. "The thylacine is perhaps the best candidate for [de-extinction]," he says. His team sequenced this predator's genome as well as the genomes of several potential surrogate species, including the dunnart or marsupial mouse. They find that although 5% of the thylacines' genome is missing, that 5% is primarily repetitive regions that likely won't affect how the transformed animal looks or behaves, he says.

Moreover, sequencing is “steadily improving” for both modern and extinct DNA, says George Church, the Harvard University geneticist who helped found Colossal. “Many 100% animal genomes will be arriving faster and faster.” Gilbert now thinks creating an exact replica of a mammoth or a passenger pigeon will be “impossible.” But such efforts might lead to what the International Union for Conservation of Nature calls “proxies,” animals close enough to carry out the same function in the extinct species’ old ecosystem, such as a cold-tolerant “woolly elephant.” And that’s where Church is headed. “The main goal is not making ‘perfect photocopies,’ but making diverse and selective hybrids,” he explains. Right now, his team is focused on defining the mammoth’s cold-tolerance genes for transferring into elephants.

Herridge cautions that in most cases scientists won’t know in advance how the edited genes will affect the animal’s behaviour and ability to survive. McCauley and others also think de-extinction efforts may take needed resources away from conservation. “You can save eight extant species for [the cost of] one that you make de-extinct,” Wendling points out.

Liz Pennisi is a senior correspondent covering many aspects of biology for *Science*.

[Adapted: (<https://www.science.org/content/article/bringing-back-woolly-mammoth-and-other-extinct-creatures-may-be-impossible>)]