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ST DOMINIC'S SCHOOL FOR GIRLS

GRADE 12 LIFE SCIENCES

PRELIMINARY EXAMINATION PAPER 2

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SOURCE BOOKLET

QUESTION 1

SOURCE 1

Evolving Before Our Eyes: Songbirds bolster Darwin's theory that change in habitat can create 2 species from one

By David Perlman, Chronicle Science Editor March 26, 2001

When Charles Darwin pondered the wonderfully diverse beaks and bodies and lifestyles of the finches on the Galapagos Islands, he wrote these classic words:

"Seeing this gradation and diversity of structure in one small, intimately related group of birds, one might really fancy that from an original *rareness* of bird *species*, one species had been taken and modified for different ends."

It was an idea that was to strike him again and again because, in the 13 different species of Galapagos finches, the young naturalist saw the living results of creatures adapting to pressures imposed by varying environments.

Now three California scientists, led by Darren Irwin of the University of California at San Diego, have explored a very different race of birds around the Himalayan mountain range. The scientists say they have discovered the most compelling evidence yet to buttress the theory Darwin elaborated in his epochal volume "The Origin of Species," which ignited a revolution in human thought.

Irwin's Eurasian songbirds are known as "ring species" because their forms have gradually altered as their populations have settled around a geographic ring of varied habitats and adapted over time to the demands of their different environments.

Irwin and his colleagues tracked a single species of the drab songbirds called Greenish Warblers that settled to nest and breed in forest habitats encircling Asia's treeless Tibetan Plateau. The researchers have found an evolutionary surprise:

The warbling songs of the birds differ slightly in each habitat, their body sizes vary, their wing markings change, and even their genes have diverged further and further apart. However, populations of warblers, like other birds, easily mate and interbreed with neighbouring groups around the ring. But when Irwin studied two separate populations of the birds that coexist in Siberia far from their original range, he found that they do not mate at all, and they differ strikingly in other characteristics.

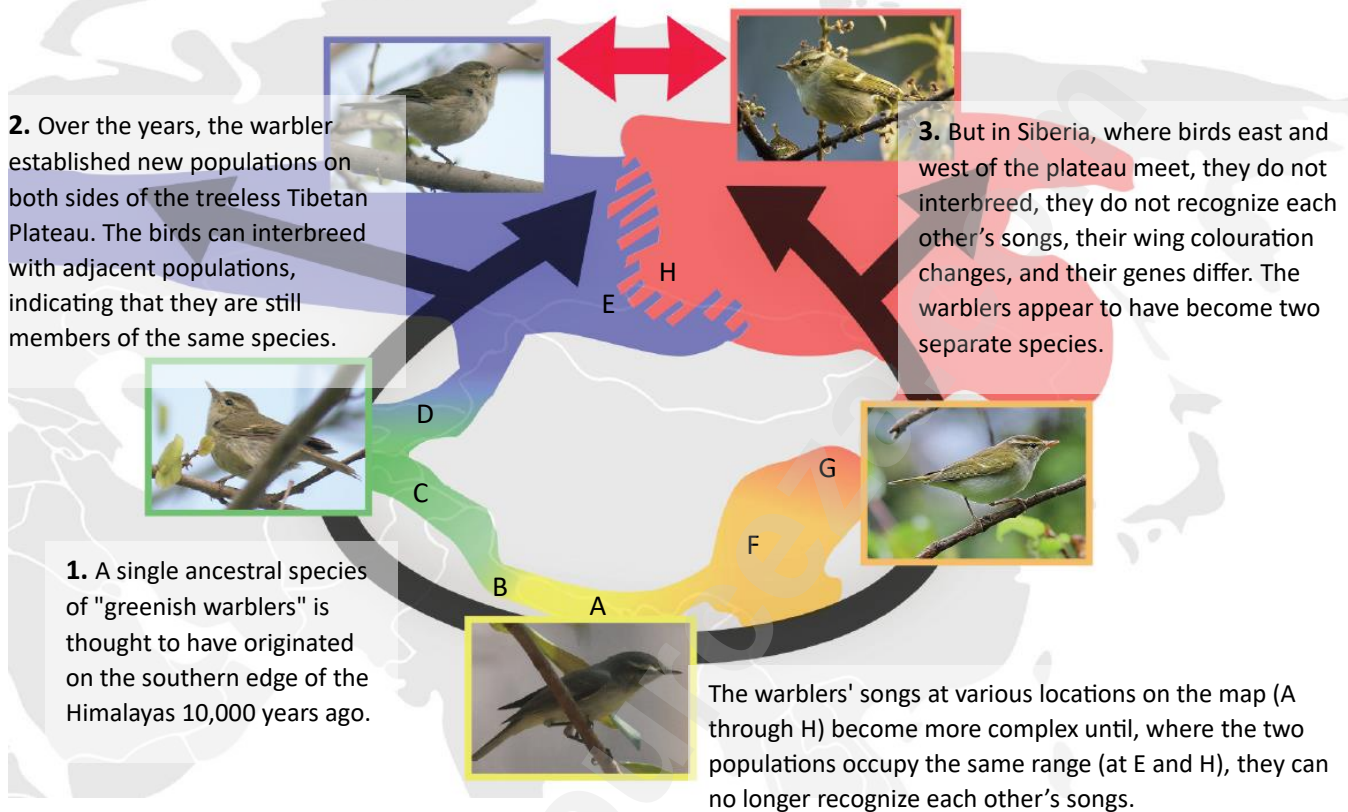
What had clearly been a single songbird species now bore all the signs of having evolved into two distinct species.

To meet such extremely different environments, the birds, it seems, had indeed been "modified for different ends," as Darwin put it more than 150 years ago. Irwin's remarkable evidence of evolution in the birds called *Phylloscopus trochiloides* was published in a recent issue of the journal Nature.

The team also recorded the warblers' songs, and in each habitat Irwin played the male birds' songs back to the females - sometimes to their puzzlement, sometimes to their anger, but often to their sexually eager response, Irwin found.

"One of the largest mysteries remaining in evolutionary biology is exactly how one species can gradually diverge into two," Irwin says. "And I'm sure that Darwin would be pleased at what we've found, because he always lacked the evidence that a species could change gradually as its members diverged and became isolated from each other. But now we have that evidence."

Biologists have discovered two populations of Eurasian songbirds in Siberia that show the strongest evidence yet of having evolved from a single ancestral species into two distinct ones. The map below shows the present ranges of the birds around the Tibetan Plateau, with gradations of colour indicating where gradual changes have evolved between one subspecies and another.

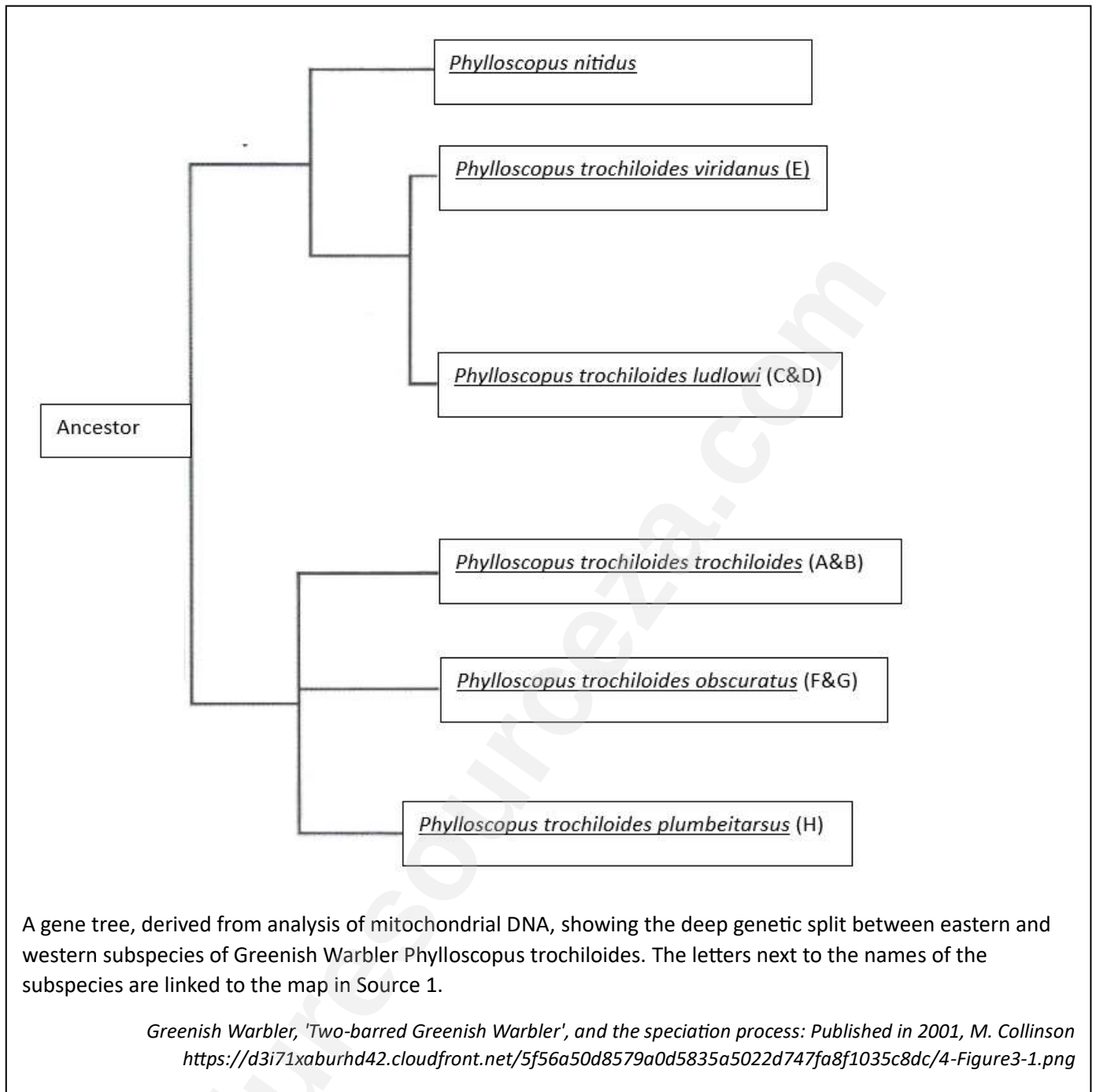


[Source: The journal Nature Todd Trumbull / The Chronicle]

SOURCE 2

Now, this previous evidence is combined with molecular approaches that can measure the amount of gene flow between different lineages. It turns out that, sometimes, a classic species based on external features matches the patterns from protein and DNA sequences, which confirms previous taxonomic work. But, in some cases, a single species with the same external features may contain cryptic molecular lineages, which hints at a more complex evolutionary history.

Bay Area herpetology: salamanders, part 2-Nick Pyenson Apr 12, 2007



SOURCE 4



Phylloscopus trichiloides viridanus from region E on the map. Has a large hooked beak for catching flying insects.



Phylloscopus trichiloides plumbeitarsus from region H on the map. Has a smaller beak for catching insects living on the ground.

SOURCE 1

In the first half of the 20th century, the region thirty miles northwest of Johannesburg, South Africa, produced so many fossils of our early ancestors that it became known as the Cradle of Humankind. It was declared a World Heritage Site in 1999. The Sterkfontein Caves in this area contain the discovery of a 2,3-million-year-old fossil *Australopithecus africanus* (nicknamed "Mrs. Ples"). Sterkfontein alone has produced more than a third of early hominid fossils ever found prior to 2010. Nearby this site, the Rising Star Cave system contains the Dinaledi Chamber (chamber of stars) in which were discovered fifteen fossil skeletons of an extinct species of hominid, named *Homo naledi*. The Dinaledi Chamber contains over 1 500 *H. naledi* fossils, the most extensive discovery of a single hominid species ever found in Africa.

Lee Berger, an American paleoanthropologist started working at the University of the Witwatersrand in the early 1990s and began to hunt for hominid fossils. But the spotlight in human evolution had long since shifted to the Great Rift Valley of East Africa. Most researchers regarded South Africa as an interesting side story to human evolution but not the main plot. Berger was determined to prove them wrong.

What he most wanted to find were fossils that could shed light on the main outstanding mystery in human evolution; the origin of our genus, *Homo*, between two million and three million years ago. On the one side are the apelike australopithecines, such as *Australopithecus afarensis* (3,85 – 2,95 mya) and its most famous representative, Lucy, a skeleton discovered in Ethiopia in 1974. On the other side is *Homo erectus* (2 mya – 100 000 years ago), a tool-wielding, fire-making, globe-trotting species of the "out of Africa" hypothesis with its big brain and body proportions much like ours. Within that almost million-year gap between them, a bipedal animal was transformed into a self-aware human being, *Homo sapiens*, a creature not just adapted to its environment but able to apply its mind to master it. How did that evolution happen?

The fossil record is frustratingly unclear. Slightly older than *H. erectus* is a species called *Homo habilis*, or "handy man" – because it is believed to be responsible for the stone tools that were found at Olduvai Gorge in Tanzania. Berger has long argued that *H. habilis* was too primitive to deserve its privileged position at the root of our genus. Some other scientists agree that it really should be called *Australopithecus*. But Berger has been nearly alone in arguing that South Africa was the place to look for the true earliest *Homo*. Then, in 2008, he made a truly important discovery. In Malapa, he and his nine-year-old son, Matthew, found some hominid fossils. Dated to about 2 million years ago, they were the first major finds from South Africa in decades. In most ways, they were very primitive, but they had some oddly modern traits too. Berger decided the skeletons were a new species of australopithecine, which he named *Australopithecus sediba*.

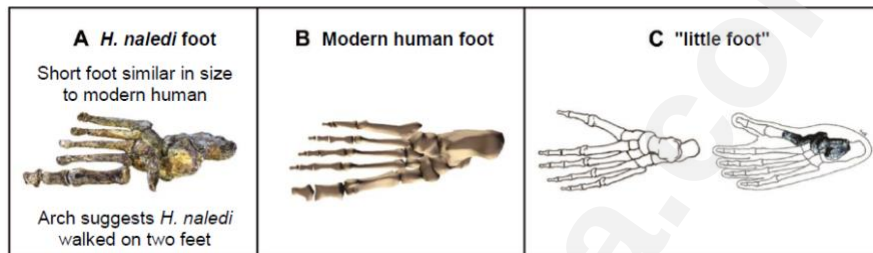
Then in 2012, some cavers discovered bones in the Rising Star Cave system. Parts of the skeletons looked astonishingly modern. But other parts were just as astonishingly primitive – in some cases, even more apelike than the australopithecines.

[Adapted from: <<http://news.nationalgeographic.com>>]

Two important features of *Homo naledi*

1. The general structure of the head looks advanced enough to be called *Homo* but their braincases were tiny – a mere 560 cubic centimetres for the males and 465 cubic centimetres for the females. This is far less than *H. erectus*'s average of 900 cubic centimetres, and well under half the size of our own (*Homo sapiens*) (1350 cubic centimetres). A large brain is the key to humanness, representative of a species that has evolved to live by its wits.
2. The feet were virtually indistinguishable from our own. Except for the slightly curved toes, the arches suggest an efficient long-distance stride.

Diagrams showing the feet of A- *Homo naledi*; B- modern human; C- Little Foot



[Adapted from: <<https://www.researchgate.net>>]

SOURCE 3

Summary of important features of *Homo naledi*.

HOMO FEATURES

Human-like skull
The general shape of *H. naledi*'s skull is advanced, though the braincase is less than half of a modern human's.

Versatile hands
H. naledi's palms, wrists, and thumbs are humanlike, suggesting tool use.

Long legs
The leg bones are long and slender and have the strong muscle attachments characteristic of a modern bipedal gait.

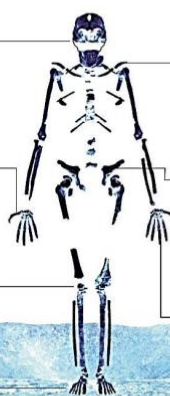
Humanlike feet

AUSTRALOPITHECINE FEATURES

Primitive shoulders
H. naledi's shoulders are positioned in a way that would have helped with climbing and hanging.

Flared pelvis
The hip bones of *H. naledi* flare outward – a primitive trait.

Curved fingers
Long, curved fingers, useful for climbing in trees



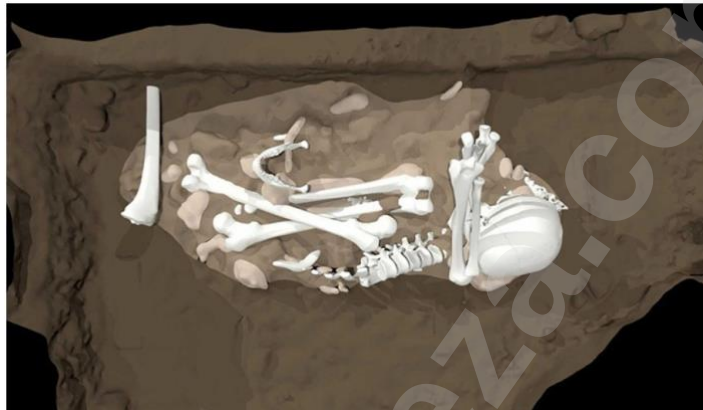
The skeletons revealed that the new human species had a curious mix of features. They had feet, hands and wrists that appeared more similar to modern humans and Neanderthals, but an upper body and brain size more like that of the archaic pre-human australopithecine species. This combination of human and pre-human features sparked a debate about where they should fit on the evolutionary tree: Were they more like our own species, or our ape-like ancestors?

[Adapted from: <<http://news.nationalgeographic.com>>]

[Natural History Museum: By Josh Davis First published 5 June 2023]

Feeding into this debate have been questions about the behaviour that *H. naledi* might have shown. The researchers who first described the discovery argue that as the remains were found so deep within the cave system that they must have been intentionally put there by other members of the species. This raises a lot of intriguing questions about how the species behaved, and whether it had human-like culture.

The researchers are now claiming that not only did the ancient humans intentionally place the bodies within the cave, but they actually buried some of the remains in shallow holes. In addition to this, they are arguing that a series of markings on the walls of the cave showed that the ancient humans were engraving the cave walls.



© Images from Berger et al., 2023

If this is confirmed as a burial then at 300,000 years old it would be the oldest human burial ever discovered. It would also mean that the ancient hominins were far more organised, and potentially had culture being passed from generation to generation.

‘They would have had to take something down there to dig the holes with. Someone is making fire torches and keeping them alive for the time they are down there. It really is complex and planned behaviour. Then you come on to the question of could a creature with no language do this, and that is a whole other can of worms to open.’

Did Homo naledi create art?

On the wall of one of the caverns are patterns of lines engraved in the rock. While the engravings are impossible to date at the moment, the researchers are arguing that because only *H. naledi* remains have been found in the caves, they are most likely to have been produced by the ancient hominin.



© Images from Berger et al., 2023

[Natural History Museum: By Josh Davis First published 5 June 2023]

SOURCE A

1. **Devolution, de-evolution**, or backward evolution (not to be confused with dysgenics) is the notion that species can revert to supposedly more primitive forms over time.

[https://en.wikipedia.org/wiki/Devolution_\(biology\)](https://en.wikipedia.org/wiki/Devolution_(biology))

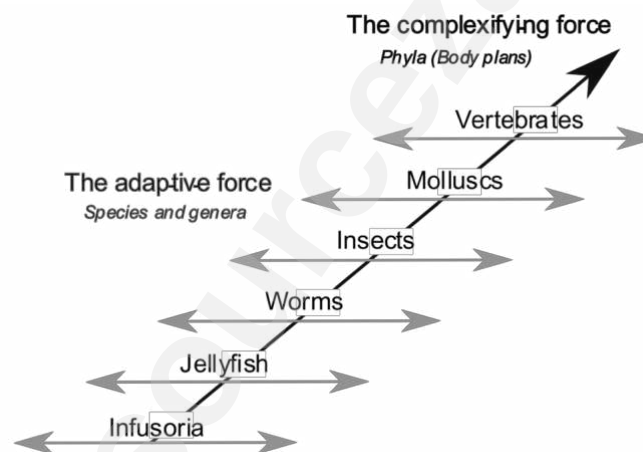
2. In biology, **evolution** is the change in the characteristics of a species over several generations and relies on the process of natural selection.

<https://www.yourgenome.org/facts/what-is-evolution/>

3. **Natural selection** is the differential survival and reproduction of individuals due to differences in phenotype. It is a key mechanism of evolution, the change in heritable traits of a population over time. Variation exists within all populations of organisms.

<https://en.wikipedia.org>

SOURCE B



Lamarck's theory of evolution involved a complexifying force that progressively drives animal body plans towards higher levels, creating a ladder of phyla, as well as an adaptive force that causes animals with a given body plan to adapt to circumstances (use and disuse, inheritance of acquired characteristics). Popular views of Lamarckism only consider an aspect of the adaptive force. The idea of progress in such theories permits the opposite idea of decay, seen in devolution. The concept relates to the idea that evolution has a purpose (teleology) and is progressive (orthogenesis), for example that feet might be better than hooves or lungs than gills.

[[https://en.wikipedia.org/wiki/Devolution_\(biology\)](https://en.wikipedia.org/wiki/Devolution_(biology))]

Can Evolution Run in Reverse? A Study Says It's a One-Way Street

By CARL ZIMMER. SEPT. 28, 2009

The Belgian biologist Louis Dollo was the first scientist to ponder reverse evolution. "An organism never returns to its former state," he declared in 1905, a statement later dubbed Dollo's law. To see if he was right, biologists have reconstructed evolutionary history. In 2003, a team of scientists studied wings on stick insects. They found that the insects' common ancestor had wings, but some of its descendants lost them. Later, some of those flightless insects evolved wings again.

Yet this study did not necessarily refute Dollo's law. The stick insects may indeed have evolved a new set of wings, but it is not clear whether this change appeared as reverse evolution at the molecular level. Did the insects go back to the exact original biochemistry for building wings, or find a new route, essentially evolving new proteins?

Dr. Thornton, a Biology professor at the University of Oregon, studied a protein called a **glucocorticoid receptor** that helps humans and most other vertebrates cope with stress by grabbing a hormone called cortisol and then switching on stress-defence genes.

By comparing the receptor to related proteins, the scientists reconstructed its history. Some 450 million years ago, it started out with a different shape that allowed it to grab tightly to other hormones, but only weakly to cortisol. Over the next 40 million years, the receptor mutated in many areas and changed shape, so that it became very sensitive to cortisol but could no longer grab other hormones.

Dr. Thornton reasoned that if he carried out the reverse mutations, he could turn a new glucocorticoid receptor into an ancestral one. To Dr. Thornton's surprise, the experiment failed. "All we got was a completely dead receptor," he said.

Dr. Thornton and his colleagues concluded that the ancestral receptor had five restrictive mutations which may have fine-tuned how the receptor grabbed cortisol. Once the restrictive mutations evolved, they made it practically impossible for the receptor to evolve back to its original form.

"I would never say evolution is never reversible," Dr. Thornton said. But he thinks it can only go backward when the evolution of the trait is simple, like when a single mutation is involved. When new traits are produced by several mutations that influence one another, he argues, that complexity shuts off reverse evolution.

[<https://www.nytimes.com/2009/09/29/science/29evol.html>]

REVERSE EVOLUTION – Clayton Graham**26th October 2017 | Life on Earth**

If it is advantageous to lose an appendage or a faculty in order to operate in a severely changed environment, then moving backwards may be the wise thing to do.

1. Hagfish are almost blind, finding their way around the seafloor primarily using their sense of smell and touch. Now, in a shock to biologists, research on a 300-million-year-old hagfish fossil reveals that the animals once had working eyes—but evolution took them away. Whatever for? Incidentally, the hagfish (see picture) is the only known animal with a skull but no backbone, and is now completely blind. However, the hagfish is thought to be in the process of evolving sight yet again. A strange cycle, presumably dictated by surroundings.



2. Modern penguins retain signatures of their airborne relatives, including wing bones, a pointy keeled breastbone for wing muscle attachments, and feathers. Losing flight made penguins better suited to their environment, because it meant that the birds could get bigger. Flightless penguins evolved bigger muscles to better power through the water, denser bones that added strength and reduced buoyancy, and shorter, stiffer wings for more powerful swimming strokes with less drag. That makes more sense. But flying birds appear to have an easier existence than the poor penguin, which can really struggle on land. Not sure why they really moved away from flight!



3. Carp and Scales: Evolution can be quick when it needs to be. Medieval European monks selectively bred carp centuries ago to produce ones with fewer scales, thus making them easier to gut and cook. Starting in 1912, the “mirror carp”— named for their smooth sides—were introduced to Madagascar, where no carp existed, for fish farming. They quickly spread throughout the island. However, by the late 1950s, people observed the mirror carp’s descendants “degenerating” into more scaled fish. 65% of the wild carp, descended from the original mirror carp released into the wild, were fully scaled, despite all still carrying the genetic mutation that originally turned their ancestors into mirror carp. This all happened in a mere 100 years, or 40 carp generations.

From a biological perspective, there is no such thing as devolution. All changes in the gene frequencies of populations--and quite often in the traits those genes influence--are by definition evolutionary changes. The notion that humans or animals might regress or "devolve" presumes that there is a preferred hierarchy of structure and function--say, that legs with feet are better than legs with hooves or that breathing with lungs is better than breathing with gills. But for the organisms possessing those structures, each is a useful adaptation.

More than 99 percent of all species that ever lived are extinct, so most species do not adapt to changing environments successfully. When species do evolve, it is not out of need but rather because their populations contain organisms with variants of traits that offer a reproductive advantage in a changing environment.

Another misconception is that increasing complexity is the necessary outcome of evolution. In fact, decreasing complexity is common in the record of evolution. For example, the lower jaw in vertebrates shows decreasing complexity, as measured by the numbers of bones, from fish to reptiles to mammals. Evolution, not devolution, selected for those adaptations.

[National Geographic, June 2016]

SOURCE F

Researchers Say They're Getting Closer to Creating a Dino-Chicken

Talk of a "chickenosaurus" lit up the science world last week when researchers announced they had modified the beak of a chicken embryo to resemble the snout of its dinosaur ancestors. But turning a beak into a snout is just one of many modifications needed to revert a chicken into a dinosaur.

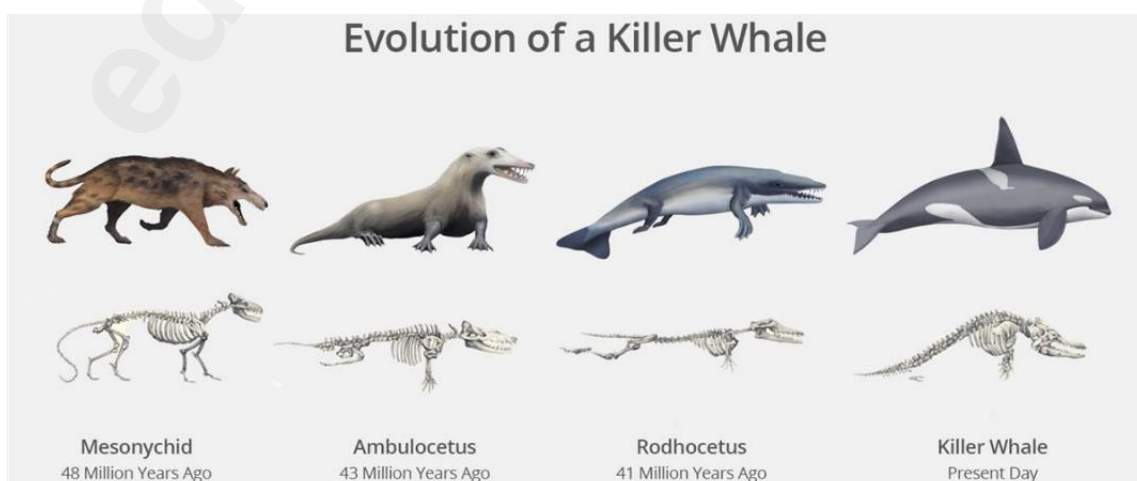
"From a quantitative point of view, we're 50 percent there," said Jack Horner, a professor of palaeontology at Montana State University and a curator of palaeontology at the Museum of the Rockies.

Horner has long supported the idea of modifying a chicken to look like a dinosaur, and unlike the researchers on the latest study, he actually wants to raise a live one. To turn a chicken into a dinosaurlike beast, scientists would have to give it teeth and a long tail, and revert its wings back into arms and hands.

Horner and his colleagues are currently working on giving the chicken a long tail— arguably, the most complex part of making a dino-chicken. They just screened genes in mice to determine what types of genetic pathways block tail development. This knowledge could help them figure out how to switch on tail growth.

[<https://www.nbcnews.com/science/weird-science/how-researchers-are-looking-ahead-dawn-dino-chicken>]

SOURCE G



Misconceptions about evolution

Myth 1: Species evolve because they need to in order to adapt to environmental changes.

Biologists refer to this misconception as teleology, the idea of intrinsic finality that things are "supposed" to be and behave a certain way, and naturally tend to act that way to pursue their own good. As the fossil record demonstrates that more than ninety nine percent of all species that ever lived are now extinct it is clear that most species do not evolve despite radical environmental changes. From a biological viewpoint, when species evolve it is not a reaction to necessity, but rather that the population contains variations with traits that favour their natural selection.

Myth 2: Evolution means progress to more advanced organisms.

This presumes that there is somehow a preferred hierarchy of structure and function, for example that "feet are better than hooves" or "lungs are better than gills", and can lead to the idea that change to "less advanced" structure can be called "devolution". To biologists this is an aspect of teleology, the supposition that there is purpose or directive principle in the works and processes of nature. A biologist sees all such changes as evolution, since for the organisms possessing the changed structures, each is a useful adaptation to their circumstances. For example, hooves have advantages for running quickly on plains as horses do, and feet have advantages in climbing trees as the ancestors of humans did.

Myth 3: Humans are the ultimate product or goal of evolution.

This belief is related to anthropocentrism, the idea that human existence is the point of all universal existence, and is a variation on the idea of "progress". To a biologist, describing the biological evolutionary process as goal-oriented would seem as ludicrous as a physicist claiming that the ultimate goal of gravity is to keep the Earth in its present orbit.

Myth 4: Increasing complexity is the necessary outcome of evolution.

Biologists have evidence of many examples of decreasing complexity in the record of evolution. The lower jaw in fish, reptiles and mammals has seen a decrease in complexity, if measured by the number of bones. Ancestors of modern horses had several toes on each foot; modern horses have a single hoofed toe. Modern humans may be evolving towards never having wisdom teeth, and already have lost the tail found in many other mammals - not to mention other vestigial structures, such as the vermiform appendix or the nictitating membrane.

[https://www.bionity.com/en/encyclopedia/Biological_devolution.html]

The Wrists of Birds Reveal Evolution Undoing Itself :

By Elizabeth Quill, Smithsonian Magazine, February 2015

Contrary to earlier claims, a new study shows that evolution may be reversible.

Are you sitting down? Good, because you may be shocked to learn that evolution can retrace its steps. A recent study of the wrists of modern birds finds that a bone lost from dinosaurs for tens of millions of years reappeared when dinosaurs evolved into birds and took flight.

In the four-legged ancestors of dinosaurs, wrists were robust, weight-bearing joints with as many as 11 bones. When two-legged dinosaurs evolved some 230 million years ago, though, the wrists, no longer supporting such weight, became comparatively dainty. The forelimbs of the meat-eating raptors took on the task of manipulating prey, and the number of wrist bones shrank to just three. Among those that disappeared was a knobby bone called the pisiform.

Alexander Vargas of the University of Chile and his team decided to investigate the next steps in this evolutionary tale by studying not just fossils but also embryos of today's birds, including chickens, pigeons and parakeets. Ancestral features are often visible in a developing embryo.

When meat-eating dinosaurs evolved into birds, the wrist joint in the wing, between the middle and final segments, morphed again—increasing flexibility so the wing could fold back against the body. Birds also evolved a bone in the same place as the pisiform, to transmit force to the wing. Anatomists deemed it a new bone, the ulnare.

But in analysing the development of the ulnare, Vargas showed that it is, in fact, the re-emergence of the pisiform.

“While the physical expression of a gene may be suppressed, it doesn’t mean the possibility of generating that structure has disappeared,” says Luis Chiappe, director of the Dinosaur Institute at the Natural History Museum of Los Angeles County. “The gene is still there, it’s just dormant.”