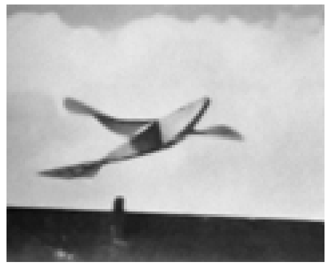
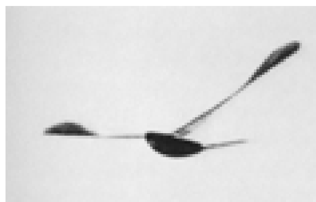
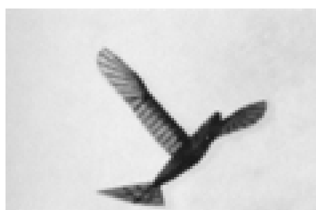
Flashback

Model Birds Learn to Fly

Aircraft require a propeller or turbines in order to take flight. Birds simply flap their wings. Erich von Holst, Founding Director of the Max Planck Institute for Behavioral Physiology in Seewiesen, researched how birds propel themselves in the air – by simulating their air travel with models. However, bird flight was only a side interest for the physiologist; his main area of work was in comparative behavioral biology. Von Holst's contribution to this discipline was almost entirely overshadowed by that of his colleague Konrad Lorenz – wrongly so.







Von Holst used numerous models to imitate bird flight.

Photos: Werner Nachtigall, Vogelflug und Vogelzug, Rasch und Röhrig Verlag, Hamburg 1987

The beginning of their acquaintance was anything but an amiable encounter: "Idiot, idiot," grumbled von Holst from the back row of the Harnack House in Berlin. Sitting next to him was Margarethe Lorenz, while her husband Konrad was delivering a lecture on the cultivation of instinct. The Austrian anatomist and animal psychologist Konrad Lorenz was 32 years old at the time. At the invitation of the Kaiser Wilhelm Society, he was explaining how animals were able to achieve certain goals by means of variable, purpose-oriented behavior. Lorenz emphasized, however, that this was not the same thing as determination – as he put it, an animal achieves its purpose simply by allowing inborn movements to run their course. Von Holst was largely in agreement with Lorenz up to this point. But when Lorenz concluded his lecture by stating that such instinctive movements were based on chain reflexes, von Holst scoffed.

As a biologist, Erich von Holst regarded this reflex theory as misguided. Lorenz later claimed that the subsequent dispute in a restaurant lasted just ten minutes; observers say the argument was a lengthy one. By the end of it, Erich von Holst – five years younger than Lorenz – had convinced his older colleague that the generally accepted reflex theory could not possibly be accurate. According to von Holst, when an animal follows its instinct, it is not a complex chain of reflexes taking place, but the product of physiological systems that act independently of the environment, similar to a heart pacemaker. A reflex, on the other hand, is a response to an external stimulus.

Von Holst had made this discovery during experiments with earthworms: He cut a worm into segments, attached a sensitive voltmeter to each segment and observed the deflections of the voltmeters. Although the segments no longer had any contact with each other or with the worm's "brain," the voltmeters showed a distinct consecutive series of deflections. A potential wave was running through the severed pieces of the worm from the front to the end of the entire cut-up specimen at approximately the speed of the contraction wave of a crawling worm. This proved that its movements were determined by autonomous inner rhythms and not by a reaction to environmental stimuli.

The theory that von Holst proved in this way provided answers to a number of unsolved questions relating to behavioral biology that reflex theory could not explain. For example, the mating behavior of a single animal species consists of the same gestures and postures. The courtship process thus cannot be a response to external stimuli. On the contrary: the animal acts on an inborn instinct that developed over the course of evolution.

Animal psychology, having previously been concerned with observation and description, now began to increasingly develop into a physiology of behavior. It appears that von Holst's unfriendly remarks about Lorenz gave a considerable boost to comparative behavioral research.

Erich von Holst and Konrad Lorenz would later also come together professionally: von Holst became a Scientific Member of the newly founded Max Planck Institute for Marine Biology in Wilhelmshaven in 1948, while Lorenz was appointed Head of the Research Center for Behavioral Physiology, which was associated with this same institute and located in Buldern, near Münster. In 1954, the Senate of the Max Planck Society decided to combine the disciplines of the two scientists to form a new institute: the Max Planck Institute for Behavioral Physiology in Seewiesen. Erich von Holst became the Managing Director of the Institute and Konrad Lorenz his deputy. Von Holst headed the institute from its foundation in 1958 until his untimely death in 1962, after which Lorenz took up the post.

The two men shared yet another area of interest in their work: bird flight. The topic took center stage in Konrad Lorenz's doctoral thesis in zoology – more precisely, his second doctorate, completed in 1933, five years after having earned his first one in medicine. Lorenz published the thesis under the title "Observations on the flight of birds." Appearing in the Journal of Ornithology in 1933, the study was described as "the best thing written on avian flight since Otto Lilienthal." Another critic praised Lorenz's study as being "excellently observed, without being worded in abstract mathematical terms, and demonstrating an extremely fine sensitivity." There were, however, those who did not agree with Lorenz's explanations – including the young Erich von Holst.

Von Holst, too, was a good observer, but he was also an outstanding experimenter. He demonstrated this to great effect in his work on bird flight – and during his leisure pursuits. Not only was he an excellent viola player, he also crafted musical instruments himself. His aim in doing so was to explore the laws of sound production. And he applied the same principle to avian flight: his observations of birds provided the ideas for his flight models.

Von Holst was well aware that his experiments with models did not provide conclusive evidence – the fact that a bird model successfully moves through the air without crash-landing does not demonstrate an understanding of how a bird flies. However, von Holst was actually able to use the models to try out his ideas. Design errors were immediately obvious, since they prevented the models from flying as aesthetically as their natural counterparts.

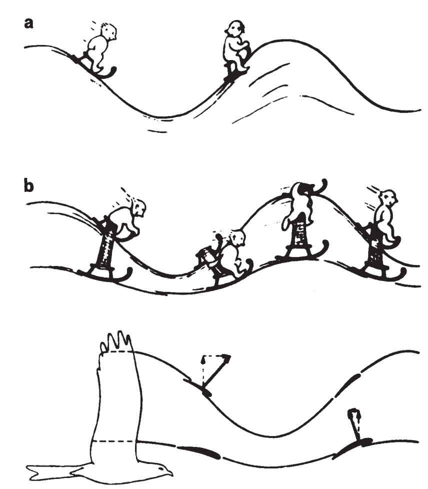
Von Holst and his staff tested a variety of gear mechanisms to achieve winged flight – some of them entirely original in design. They also experimented with many different wing motion sequences to imitate the various forms of bird flight. The advantage was that they could freely adapt all the parameters that affected how the models flew.

According to zoologist and avian flight researcher Werner Nachtigall, Erich von Holst made the same assumption as Otto Lilienthal before him: that the various sections of the wing describe different paths during upward and downward movement. Supposing one section of the wing generates downforce when lifted, this ought to be compensated with additional lift force on the next downstroke of the wing. However, this lift need not necessarily be produced by the same section of the wing. For example, the armwing – the part of the wing closest to the bird's torso – might generate downforce; but on the subsequent downstroke, this downforce could be compensated for by the handwing, that is the tip of the wing.

Von Holst came up with a concept to illustrate this complex process: "Imagine the path traced by the wing solidified into a chain of identical snow-covered hills; and instead of the bird, imagine a young boy on a sleigh. The boy wishes to glide smoothly over each hill in succession – just as the bird is apparently able to. But to his disappointment, he discovers that his momentum is insufficient – he repeatedly comes to a standstill just before he reaches the peak of the next hill."

The boy then has an idea: He takes a plank of wood and attaches a second sleigh to the original one. The second sleigh moves alongside the first, but over flatter land. The boy is now able to change from one sleigh to the other. For the downhill ride, he sits on the first sleigh, while in the valley he slides nimbly along on the second. He then has enough momentum to overcome the much less steep gradient. When he reaches the top of the hill, he quickly climbs over onto the first sleigh and the whole process begins again. This is the principle that governs bird flight.

Von Holst repeatedly discarded theories of flight for many years, constantly replacing them with new ones. And many flight models were wrecked in the process. But his persistent efforts did not go unrewarded. To his great satisfaction, he finally created a large, artificial bird that flew reliably and elegantly across a field. The model is said to have looked so deceptively authentic that smaller birds were scared away, field mice scurried into their holes and crows even bashfully flirted with it. Von Holst's students were highly entertained when he flew his models in the lecture hall.



This was the "sleigh model" used by von Holst to illustrate how a bird's wings work.

In this way, von Holst created a whole range of models, imitating the flight of everything from dragonflies to pterosaurs. In order to simulate the flight patterns of these ancient airborne lizards, he started by studying pterosaur fossils, examining the base and shape of their wings. He eventually managed to construct models of a pterosaur with flapping wings and was able to use these to demonstrate that the creatures must have been good at both flapping flight and gliding. He also presented these publicly to great acclaim – for example to the astounded delegates of the German Paleontology Conference in 1956.

MICHAEL GLOBIG

Frankfurter Allgemeine Zeitung of Dec. 20, 1989

Pterosaurs – Agile Creatures of the Air

The findings of the American researcher sound impressive. However, they have one flaw: they are not new. (...) As many as thirty years ago, German zoologist, physiologist and flight biologist Erich von Holst of the Max Planck Institute for Behavioral Physiology (...) studied pterosaurian flight using fossils. He even presented a model of a flying Rhamphorhynchus pterosaur with flapping wings, and made a scientific film of his demonstration.