Evolution

When antlers grew too large

With antlers that can spread 2 meters, moose are the giants of the modern deer universe, but these big-nosed browsers pale in comparison with the extinct Irish elk. An ice age inhabitant of Europe and Asia, the Irish elk evolved antlers reaching 3 meters across and weighing 40 kilograms—too big for the animals' own good, according to a new analysis of antler growth.

"People have always been interested in the Irish elk because they had the largest antlers of any deer. And they have always guessed what limited antler growth and why did they go extinct when the other deer didn't," says Ron A. Moen of the University of Minnesota-Duluth.

Moen and his colleagues used physiological information about moose to analyze antler growth in Irish elk. They calculate that males deposited more than 60 grams of calcium and 30 g of phosphorus daily into the growing antlers during midsummer. Diet would have provided most of these nutrients, but not all. The remainder would have been leached out of the animal's skeleton during summer and replaced later, the researchers report in the February EVOLUTIONARY ECOLOGY RESEARCH.

Some of the largest and last Irish elk lived in Ireland itself. They went extinct there during the final phase of the ice age, a 1,000-year-long cold snap called the Younger Dryas. At that time, glaciers covered much of the island, and tundra replaced forests.

According to the physiological model constructed by Moen and his coworkers, Irish elk ran into nutritional problems during the Younger Dryas. Their diet would have provided enough calcium and protein but not enough phosphorus and total calories. The males were able to grow big antlers during summer and thus could mate, but ones with the largest racks would have suffered later in the year when they could not restore their bone density or their fat reserves, says Moen.

Paleontologists have previously suggested that food limitations may have harmed Irish elk, but the new study is the first to quantify the nutritional requirements of the extinct species, says Adrian M. Lister, a paleontologist at University College London who studies Irish elk. —*R.M.*

Turtles and crocs: Strange relations

A new genetic study chops up the traditional reptile family tree by asserting that turtles are the closest living kin of crocodiles.

Generations of paleontologists have regarded turtles as outsiders among modern reptiles—holdovers from an ancient group called anapsids that lack holes in the sides of their skulls. Living reptiles and birds have two holes in the sides of their skulls and are termed diapsids. The new evidence, however, suggests that crocodiles are closer to turtles than they are to lizards, snakes, and birds—meaning that turtles sit smack in the middle of the reptile tree, rather than off to the side. S. Blair Hedges and Laura L. Poling of Pennsylvania State University in State College describe their work in the Feb. 12 SCIENCE.

These results confirm the findings from a previous molecular study that used fewer genes (SN: 12/5/98, p. 358). "It really solidifies the picture for the molecular data," says paleontologist Olivier C. Rieppel of the Field Museum of Natural History in Chicago. His own studies of fossil reptiles have also challenged the conventional interpretation of turtle origins.

Paleontologists will find other aspects of the genetic results perhaps even more disturbing than the news regarding turtles. Hedges and Poling provide some of the first DNA analysis of tuataras, a group of four-legged reptiles that look superficially like lizards and are regarded as their closest living relatives. The analysis by Hedges and Poling, however, places tuataras nearer to crocodiles than to lizards. "From a paleontological point of view, I cannot even begin to imagine how tuatara could not be [closely] related to lizards and snakes," says Rieppel. —*R.M.*

Physics

Ghostly magnetism comes from nowhere

Magnetism starts small. A substance becomes magnetic from the alignment of particles, such as some atoms or electrons that behave as tiny bar magnets. The discovery of a magnetic material with virtually no sign of such micromagnets, known as magnetic moments, has physicists stumped.

"There are just no moments other than a few free electron spins in there," says Zachary Fisk of Florida State University in Tallahassee of a variant of calcium hexaboride that he and his colleagues are studying. "It doesn't make sense" to see magnetic effects from so few elements. The researchers were probing the material's electronic traits when they made the surprising discovery reported in the Feb. 4 NATURE.

The finding revives a 60-year-old debate about the magnetic influence of low densities of electrons. Nobel laureate Eugene Wigner and others suggested how dilute clouds of so-called conduction electrons, which roam freely in a metal, might become ordered and generate magnetism. Other theorists countered that the spins of conduction electrons are usually randomly oriented, with every up spin canceled by a down spin.

Since the early 1980s, however, computer calculations have indicated that some types of magnetically effective ordering of scarse electrons can occur. Fisk and his colleagues may now have come up with experimental evidence.

The magnetism of the calcium-boron compound, which also includes a little lanthanum, is about a thousandth that of iron, Fisk estimates. Not only was that magnetism surprising, but its persistence up to 327°C has also stunned researchers.

Ordinarily, weak micromagnets fall out of alignment—canceling magnetism—at a much lower temperature than strong micromagnets. "Here that is absolutely not true," says Hans R. Ott of the Federal Institute of Technology in Zurich. The new compound's maximum magnetic temperature uncharacteristically approaches iron's, 770°C.

No atoms in the compound have the requisite electronic configurations to generate magnetic moments, Ott says. "I can't tell you how, but the moments somehow form in this very-low-density [conduction] electron ensemble." —*P.W.*

Making magnetism flip twice, by design

Novel magnetic materials are out there, waiting to be discovered, but finding them is a hit-or-miss proposition. A Japanese team now reports it may have devised a straight path from theory to materials with specific, desirable traits.

When placed in a magnetic field, some materials develop magnetism with the same polarity, while others develop an opposing field. As described in the Feb. 8 PHYSICAL REVIEW LETTERS, the team created a new powder whose magnetic polarity flips twice as temperature climbs from absolute zero.

Such a double reversal was first reported in another material last year. This time, however, the researchers deliberately chose to make their new substance with the specific trait. "This is the first case of a new magnet predicted by theory," says Kazuhito Hashimoto of the University of Tokyo and Kanagawa Academy of Science and Technology in Atsugi.

By incorporating an assortment of metal ions into a crystalline, chromium-based compound, the researchers cause polarity to flip at 35 kelvins and then flip back at 53 K. Between those temperatures, a negative magnetism takes over as one of the ion types, which aligns atomic spins contrary to an applied magnetic field, outweighs the positive responses of other ions.

The researchers expect their directed design to apply to a chemical family that includes the dye called Prussian blue. The double-flip material, a member of that family, is not likely to find practical use. However, Hashimoto and his colleagues are currently creating other magnetic materials, such as ones that respond to light, with commercial promise. —*P.W.*