

# THE ICEMAN RECONSIDERED

By James H. Dickson, Klaus Oeggl and Linda L. Handley

**O**n a clear day in September 1991 a couple hiking along a high ridge in the Alps came upon a corpse melting out of the ice. When they returned to the mountain hut where they were staying, they alerted the authorities, who assumed the body was one of the missing climbers lost every year in the crevasses that crisscross the glaciers of the region. But after the remains were delivered to nearby Innsbruck, Austria, Konrad Spindler, an archaeologist from the university there, ascertained that the corpse was prehistoric. The victim, a male, had died several thousand years ago. Spindler and other scientists deduced that his body and belongings had been preserved in the ice until a fall of dust from the Sahara and an unusually warm spell combined to melt the ice, exposing his head, back and shoulders.

No well-preserved bodies had ever been

THE ICEMAN was discovered in a rocky hollow high in the Alps, in the zone of perennial snow and ice. Pressure from the overlying ice had removed a piece of the scalp. His corpse lay draped over a boulder. Contrary to earlier assumptions, evidence indicates it had floated into that position during previous thaws.



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Where was the Iceman's home and what was he doing at the high mountain pass where he died? Painstaking research—especially of plant remains found with the body—contradicts many of the initial speculations





Ötzi had been **WARMLY DRESSED** in leggings, loincloth and jacket made of the hide of deer and goat, and a cape made of grass and bast.

found in Europe from this period, the Neolithic, or New Stone Age. The Iceman is much older than the Iron Age men from the Danish peat bogs and older even than the Egyptian royal mummies. Almost as astounding was the presence of a complete set of clothes and a variety of gear.

In the ensuing excitement over the discovery, the press and researchers offered many speculations about the ancient man. Spindler hypothesized an elaborate disaster theory. He proposed that the man had fled to safety in the mountains after being injured in a fight at his home village. It was autumn, Spindler went on, and the man was a shepherd who sought refuge in the high pastures where he took his herds in summer. Hurt and in a state of exhaustion, he fell asleep and died on the boulder on which he was found five millennia later. The beautiful preservation of the body, according to this account, was the result of a fall of snow that protected the corpse from scavengers, followed by rapid freeze-drying.

Because the uniqueness of the discovery had not been immediately evident, the corpse was torn from the ice in a way that destroyed much archaeological information and damaged the body itself. A more thorough archaeological excavation of the site took place in the summer of 1992 and produced much valuable ev-

idence, including an abundance of organic material (seeds, leaves, wood, mosses). This material added greatly to the plant remains, especially mosses, already washed from the clothes during the conservation process. Now, after a decade of labor-intensive research by us and other scientists on these plant remains and on samples taken from the Iceman's intestines, some hard facts are revising those first, sketchily formed impressions and replacing them with a more substantiated story.

### Who Was He?

THE HIKERS HAD DISCOVERED the body at 3,210 meters above sea level in the Ötztal Alps, which led to the popular humanizing nickname Ötzi. A mere 92 meters south of the Austrian-Italian border, the shallow, rocky hollow that sheltered the body is near the pass called Hauslabjoch between Italy's Schnalstal (Val Senales in Italian) and the Ventertal in Austria [see map on opposite page]. Ötzi lay in an awkward position, draped prone over a boulder, his left arm sticking out to the right, and his right hand trapped under a large stone. His gear and clothing, also frozen or partially frozen in the ice, were scattered around him, some items as far as several meters away. Radiocarbon dates from three different laboratories made both on plant remains

found with the body and on samples of Ötzi's tissues and gear all confirm that he lived about 5,300 years ago.

Certain other features of Ötzi were relatively easy to discover as well. At 159 centimeters (5'2.5"), he was a small man, as many men in the Schnalstal vicinity are today. Bone studies show he was 46 years old, an advanced age for people of his time. DNA analysis indicates his origin in central-northern Europe, which may seem obvious, but it differentiates him from Mediterranean people, whose lands lie not too far distant to the south.

In an unusual congenital anomaly, his 12th ribs are missing. His seventh and eighth left ribs had been broken and had healed in his lifetime. According to Peter Vanezis of the University of Glasgow, his right rib cage is deformed and there are possible fractures of the third and fourth ribs. These changes happened after he died, as did a fracture of the left arm. That these breakages occurred after death is among the considerable evidence that casts doubt on the early disaster theory. So does the finding that an area of missing scalp was caused by pressure, not by a blow or decay.

Holding aside the unanswered questions concerning Ötzi's death and whether it was violent or not, several sound reasons suggest that he had not been in the best of health when he died. Although most of his epidermis (the outer layer of the skin), hair and fingernails are gone, probably having decayed as a result of exposure to water during occasional thaws, his remains still offer something of a health record for modern investigators. Examination of the only one of his fingernails to have been found revealed three Beau's lines, which develop when the nails stop growing and then start again. These lines show that he had been very ill

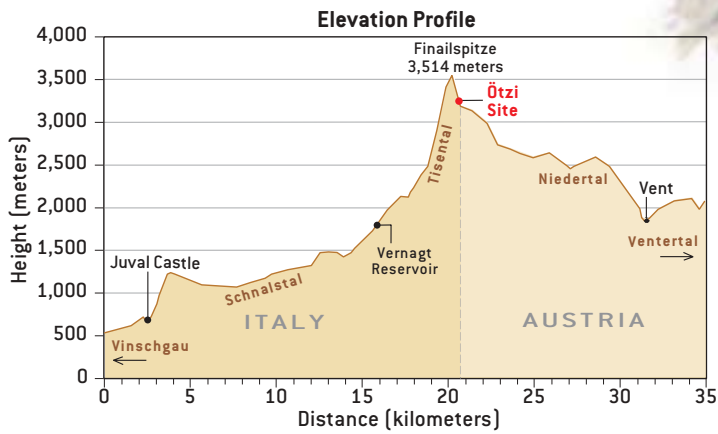
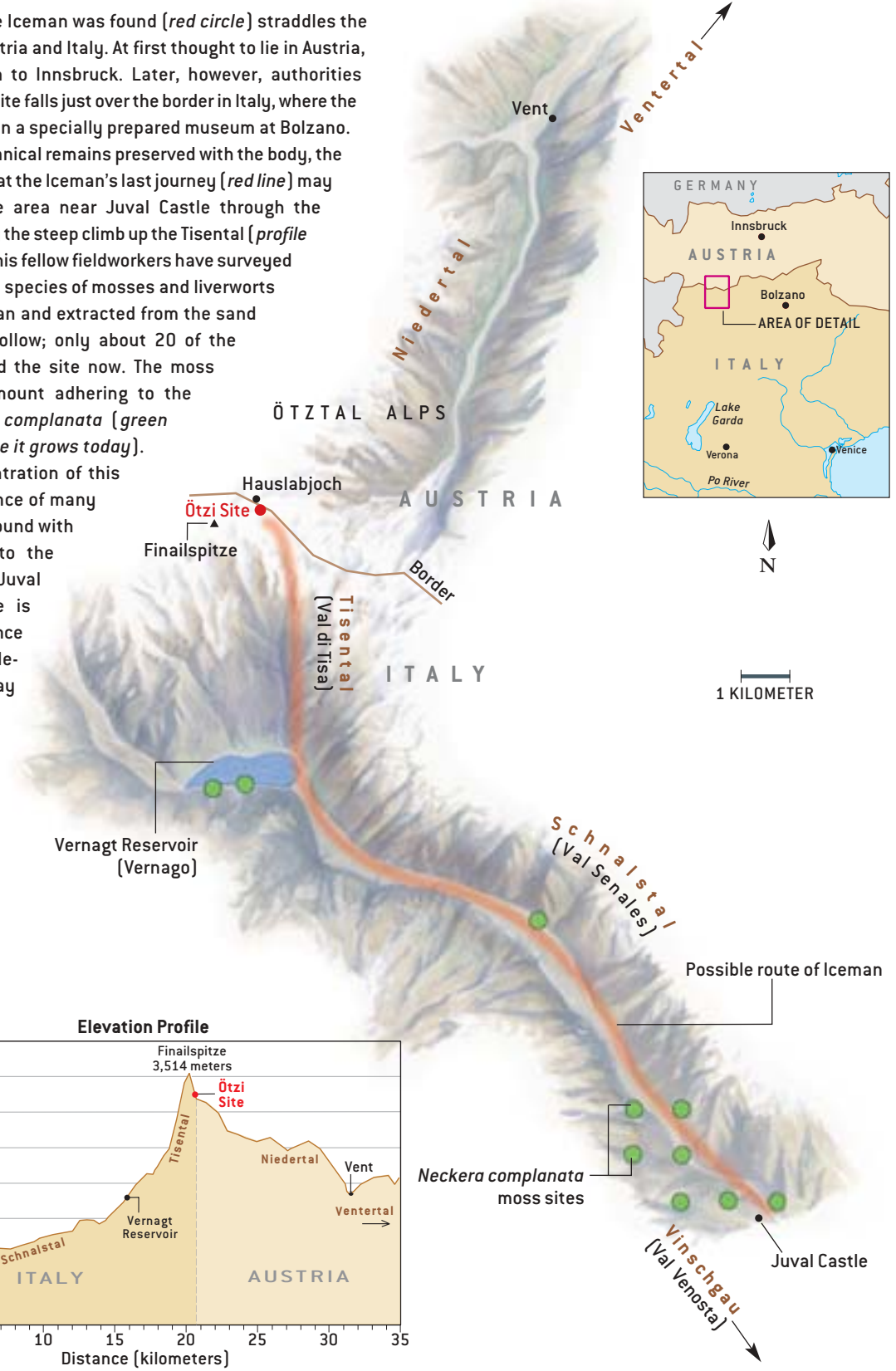
## Overview/A New Look at an Ancient Man

The most current research indicates that the Iceman:

- May have lived near where Juval Castle now stands in southern Tyrol (Italy)
- Ate a varied diet of primitive wheat, other plants and meat
- Was 46 years old and had not been in the best of health
- Died in the spring, not in the autumn as previously thought
- May have been killed by being shot in the back with an arrow
- Did not expire on the boulder where he was found, as was believed, but floated into position there during occasional thaws

# THE ROUTE THE ICEMAN MAY HAVE TAKEN

THE AREA WHERE the Iceman was found (red circle) straddles the frontier between Austria and Italy. At first thought to lie in Austria, the body was taken to Innsbruck. Later, however, authorities determined that the site falls just over the border in Italy, where the Iceman now resides in a specially prepared museum at Bolzano. Based mainly on botanical remains preserved with the body, the authors speculate that the Iceman's last journey (red line) may have been from the area near Juval Castle through the Schnalstal and finally the steep climb up the Tisental (profile below). Dickson and his fellow fieldworkers have surveyed this region for the 80 species of mosses and liverworts found with the Iceman and extracted from the sand and gravel in the hollow; only about 20 of the species grow around the site now. The moss found in largest amount adhering to the clothing is *Neckera complanata* (green circles indicate where it grows today). The greatest concentration of this moss and the presence of many of the other plants found with the Iceman occur to the south of the site, at Juval Castle, where there is archaeological evidence of a prehistoric settlement. This spot may have been his home.



# WHAT THE ICEMAN AND HIS BELONGINGS TELL US

Ötzi was small, standing only 159 centimeters (5'2.5"). Desiccation after he died shriveled the body both externally and internally. Ice pressure deformed his upper lip, nose and ears.

He was not bald in life, and he probably had a beard. The epidermis has come off, and all the hair and nails have fallen out. Some of his hair, up to nine centimeters long, was found. Analysis of the hair indicates that he ate a mixed diet of plants and animals.



The isotopic composition of the tooth enamel suggests he had lived in at least two different areas.

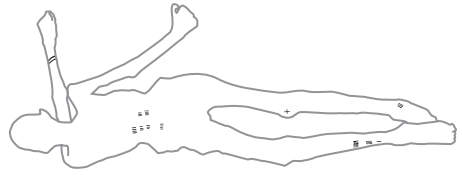
The cap was sewn of brown bearskin.



The handle of the dagger is ash wood; the flint tip may have been broken in antiquity or during the excavation.



A primitive wheat called einkorn has been identified in his gut, ground so minutely that it may well have been used to make bread. Tiny charcoal particles [fuzzy, dark shapes] suggest that the bread had been baked on an open fire.

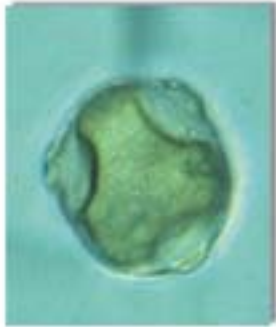


Inconspicuous tattoos, most visible on the back of the body, were simple lines and crosses that may have been intended as therapy.

Natural processes after death caused the fingers to clench. One fingernail (below) was recovered; the lines (arrows) reveal that he had been very ill three times in the months before he died.



Contents of the gut confirm that his diet was omnivorous and disclose details of his last meals (red deer, wild goat, plants and ground grains), his environment, his domicile and even his last journey.



In the gut samples, pollen grains (left) of the hop hornbeam tree (below) indicate that the Iceman died in late spring, when this small tree blooms.



Leaves of the moss *Neckera complanata*, also in the gut samples, suggest that he had wrapped his food in the moss. At top is the moss growing on a shady rock; below is one leafy stem washed from the clothes.



Radiocarbon dates of body tissues and gear (as well as plants) agree that he lived 5,300 years ago.



The oldest intact ax ever found, it has a copper head secured to the yew handle by birch glue and bound with strips of hide.



The shoes were carefully stitched from hide and insulated with grass but were in a poorly preserved state, perhaps partly as result of wear and tear during the Iceman's journey.



A pouch that probably fastened around his waist, although it was no longer in place, contained a fire-making kit, including true tinder fungus (lower left) and small flints (middle). A flint-sharpening tool is at the lower right.



## On hide thongs, he carried two pierced pieces of **BIRCH BRACKET FUNGUS**, known to contain pharmacologically active compounds.

three times in the last six months of his life and that the final episode, about two months before his death, was the most serious and lasted at least two weeks. Horst Aspöck of the University of Vienna found that he had an infestation of the intestinal parasite whipworm, which can cause debilitating diarrhea and even dysentery, although we do not know how bad his infestation was.

Moreover, many simple, charcoal-dust tattoos are visible on the layer of skin under the missing epidermis. These marks were certainly not decorative and were probably therapeutic. Several are on or close to Chinese acupuncture points and at places where he could have suffered from arthritis—the lower spine, right knee and ankle. This coincidence has led to claims of treatment by acupuncture. Yet, according to Vanezis and Franco Tagliaro of the University of Rome, x-rays show little if any sign of arthritis.

The little toe of his left foot reveals evidence of frostbite. Ötzi's teeth are very worn, a reflection of his age and diet. Remains of two human fleas were found in his clothes. No lice were seen, but because his epidermis had been shed, any lice may have been lost.

### What Was His Gear Like?

TURNING TO ÖTZI'S clothing and gear, scientists have learned not only about Ötzi himself but about the community in which he lived. The items are a testament to how intimately his people knew the rocks, fungi, plants and animals in their

immediate surroundings. And we can see that they also knew how to obtain resources from farther afield, such as flint and copper ore. This knowledge ensured that Ötzi was extremely well equipped, each object fashioned from the material best suited to its purpose.

He had been warmly dressed in three layers of clothing—leggings, loincloth and jacket made of the hide of deer and goat, and a cape made of grass and bast, the long, tough fibers from the bark of the linden tree. His hat was bearskin, and his shoes, which were insulated with grass, had bearskin soles and goatskin uppers.

He had carried a copper ax and a dagger of flint from near Lake Garda, about 150 kilometers to the south. The handle of the dagger was ash wood, a material still used for handles today because it does not splinter easily. His unfinished longbow was carved from yew, the best wood for such a purpose because of its great tensile strength. The famous English longbows used to defeat the French at Agincourt some 4,000 years later were made of yew. A hide quiver contained 14 arrows, only two of which had feathers and flint arrowheads attached, but these two were broken. Thirteen of the arrow shafts were made of wayfaring tree, which produces long, straight, rigid stems of suitable diameter; one was partly of wayfaring tree and partly of dogwood.

A belted pouch contained a tinder kit, which held a bracket fungus that grows on trees, known as the true tinder fungus, and iron pyrites and flints for making

sparks. A small tool for sharpening the flints was also found with the body. On hide thongs, Ötzi carried two pierced pieces of birch bracket fungus; it is known to contain pharmacologically active compounds (triterpens) and so may have been used medicinally. There were also the fragments of a net, the frame of a backpack, and two containers made of birch bark; one held both charcoal and leaves of Norway maple—perhaps it originally transported embers wrapped in the leaves.

### Where Was He From?

IN THIS PART OF THE ALPS, the valleys run north and south between towering ranges of mountains. Thus, the question of Ötzi's homeland resolves itself into north versus south rather than east versus west. The botanical evidence points to the south. A Neolithic site has been discovered at Juval, a medieval castle at the southern end of the Schnalstal, more than 2,000 meters lower but only 15 kilometers from the hollow as the crow flies. Archaeologists have not excavated the site in modern times, and there has been no radiocarbon dating, but Juval is the nearest place to the hollow where a number of the flowering plants and mosses associated with Ötzi now grow. We have no reason to suppose that they did not grow there in prehistoric times, and so perhaps that is the very place where Ötzi lived.

When his clothes were conserved, the washing revealed many plant fragments, including a mass of the large woodland moss *Neckera complanata*. This moss and others he had carried grow to the north and to the south of where he was found, but the southern sources are much closer. *N. complanata* grows in some abundance near Juval. Wolfgang Hofbauer of the Fraunhofer Institute for Building Physics in Valley, Germany, has discovered that this moss grows, in more moderate amounts, at Vernagt (Vernago), just 1,450 meters lower than the site and only five kilometers away.

JIM DICKSON, KLAUS OEGGL and LINDA HANDLEY share an interest in the plants that the Tyrolean Iceman may have used in his daily life. Dickson, professor of archaeobotany and plant systematics at the University of Glasgow, is recipient of the Neill Medal of the Royal Society of Edinburgh. He has written more than 150 papers and five books, including *Plants and People in Ancient Scotland* (Tempus Publishing, 2000), which he co-authored with his late wife, Camilla. Oeggl is professor of botany at the University of Innsbruck in Austria. He is an expert in archaeobotany and co-editor of the book *The Iceman and His Natural Environment* (Springer-Verlag, 2000). Handley, an ecophysiologicalist at the Scottish Crop Research Institute in Invergowrie, near Dundee, Scotland, specializes in the study of stable isotopes of carbon and nitrogen in plants and soils.

And most recently, Alexandra Schmid of the University of Innsbruck Botanical Institute discovered small leaf fragments of the moss *Anomodon viticulosus* in samples taken from the stomach. This woodland moss grows with *N. complanata* in lowermost Schnalstal.

If Juval was not his home, signs of Neolithic occupation at other locations in the immediately adjacent Vinschgau (Val Venosta), the valley of the River Etsch (Adige), offer other possibilities. In contrast, to the north, the nearest known Stone Age settlements are many tens of kilometers away, and we are not aware of any Neolithic settlements in the Ventertal or elsewhere in the Ötztal. If Ötzi's home was indeed in lowermost Schnalstal or in Vinschgau, then his community lived in a region of mild, short, largely snow-free winters, especially so if the climate was then slightly warmer.

Investigations by Wolfgang Müller of the Australian National University of the isotopic composition of the Iceman's tooth enamel suggest that he had grown up in one area but spent the last several decades of his life in a different place. Investigating stable isotopes and trace elements, Jurian Hoogewerff of the Institute of Food Research in Norwich, England, and other researchers have claimed that Ötzi probably spent most of his final years in the Ventertal or nearby valleys to the north. If these deductions can be substantiated, they are intriguing developments.

## What Did He Eat?

THE ONGOING STUDIES of the plant remains in samples taken from the digestive tract provide direct evidence of some of Ötzi's last meals. One of us (Oeggl) has detected bran of the primitive wheat called einkorn, so fine that it may well have been ground into flour for baking bread rather than having been made into a gruel. Microscopic debris of as yet unidentified types shows that he had eaten other plants as well. And Franco Rollo and his team at the University of Camerino in Italy, in their DNA studies of food residues in the intestines, have recognized both red deer and alpine ibex (wild goat). Splinters of ibex neck bones were also discovered close to Ötzi's body.

A solitary but whole sloe lay near the corpse as well. Sloes are small, bitter, plumlike fruit, and Ötzi may have been carrying dried sloes as provisions.

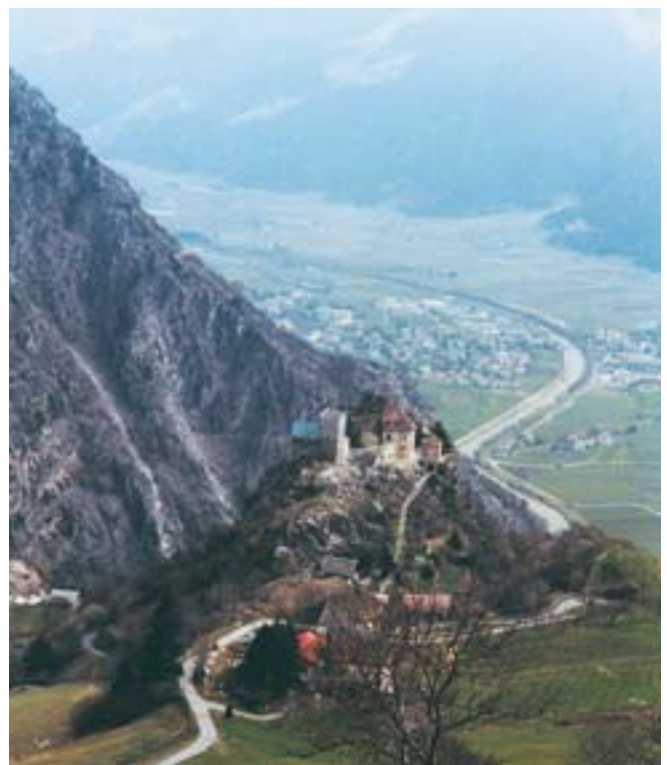
Several types of moss were recovered from the digestive tract. There is virtually no evidence that humans have ever eaten mosses, certainly not as a staple of their diet. But 5,000 and more years ago no materials were manufactured for wrapping, packing, stuffing or wiping. Mosses were highly convenient for such purposes,

as many archaeological discoveries across Europe have revealed: various mosses in Viking and medieval cesspits were clearly used as toilet paper. Had Ötzi's provisions been wrapped in moss, that would neatly explain, as an accidental ingestion, the several leaves and leaf fragments of *N. complanata* recovered from the samples taken from the gut.

Analyzing archaeological remains of bone and hair for their abundances of the stable isotopes of carbon and nitrogen



ROCK-STREWN, ICY SITE where the Iceman was found has been marked by a commemorative monument. The three men are standing on the very spot where the body lay. Typically, the snow and ice did not melt enough in the summer of 2000, when the photograph was taken, to reveal the boulders and sandy gravel on the bottom of the hollow.



JUVAL CASTLE, in lowermost Schnalstal, is the place nearest to the site where many of the low-altitude plants preserved with the Iceman grow today.

(carbon 13 and nitrogen 15) can provide information about a person's diet. Nitrogen 15 can reveal the extent to which the individual relied on animal or plant protein. Carbon 13 can indicate the type of food plant the person ate and whether seafood or terrestrial carbon was an important part of the diet.

The isotopic data agree with the other evidence that Ötzi ate a mixed diet of plants and animals. He obtained about 30 percent of his dietary nitrogen from animal protein and the rest from plants. This value is consistent with those found in hunter-gatherer tribes living today. The data also indicate that seafood was probably not a component of his diet, a finding that makes sense because of the great distance to the sea.

### What Was He Doing There?

TO THIS DAY, in what may be an ancient custom, shepherds take their flocks from the Schnalstal up to high pastures in the Ötztal in June and bring them down again in September. The body was found near one of the traditional routes, which is why early theories held that he was a

shepherd. Nothing about his clothing or equipment, however, proves that he had done such work. No wool was on or around his person, no dead collie by his feet, no crook in his hand. Some support for the shepherd hypothesis comes from the grass and bast cape, which has modern parallels in garments worn by shepherds in the Balkans, but that alone is not conclusive; for all we know, it was standard dress for travelers at that time.

Analysis of the few strands of Ötzi's hair that survived reveals very high values of both arsenic and copper. The published explanation (also given independently on television) was that he had taken part in the smelting of copper. But Geoffrey Grime of the University of Surrey in England now considers that these exceptional levels may have resulted from the action of metal-fixing bacteria after Ötzi died and that the copper was *on*, not *in*, the hair. Further support for the possibility of copper having attached itself to the hair after death comes from the presence of the moss *Mielichhoferia elongata*, called copper moss, which spreads preferentially on copper-bearing rocks. It has

been found growing at the site by one of us (Dickson) and, independently, by Ronald D. Porley of the U.K. government agency English Nature.

Another hypothesis is that Ötzi was a hunter of alpine ibex; the longbow and quiver of arrows may support this notion. If, however, he had been actively engaged in hunting at the time of his death, why is the bow unfinished and unstrung and all but two of the arrows without heads and feathers and those two broken?

Other early ideas about Ötzi are that he was an outlaw, a trader of flint, a shaman or a warrior. None of these has any solid basis, unless the pieces of bracket fungus he was carrying had medicinal or spiritual use for a shaman.

### How Did He Die?

IN JULY 2001 Paul Gostner and Eduard Egarter Vigl of the Regional Hospital of Bolzano in Italy announced that x-rays had revealed an arrowhead in Ötzi's back under the left shoulder. This assertion has led to numerous statements in the media that Ötzi was murdered and to claims from Gostner and Egarter Vigl that

THE ICEMAN was well attired in three layers of clothing fashioned from skins, grass, and bark fibers. These reconstructions were made by the archaeologists in the Roman-Germanic Museum in Mainz, Germany, where all of the Iceman's clothing and gear were restored.



JULIA RIBBECK, TAKEN FROM "DIE GLETSCHERMUMIE," RGZM

it is “now proven that Ötzi did not die a natural death, nor due to exhaustion or frostbite alone.” Although three-dimensional reconstructions of the object, which is 27 millimeters long and 18 millimeters wide, exist, requests by Vanezis and Tagliaro for the object to be removed to show convincingly that it is an arrowhead are still unanswered. Furthermore, it must be removed in a way that makes clear what fatal damage it might have done.

The arrowhead need not have caused death. Many people stay alive after foreign objects such as bullets have entered their bodies. A notable archaeological example is the Cascade spear point in the right pelvis of the famous Kennewick Man in North America; it had been there long enough for the bone to begin healing around it.

Even more recently, in a statement to the media, Egarter Vigl has reported that Ötzi’s right hand reveals a deep stab wound. No scientific publication of this finding has been made yet.

## At What Time of Year?

INITIAL REPORTS PLACED the season of death in autumn. The presence of the sloe, which ripens in late summer, near the body and small pieces of grain in Ötzi’s clothing, presumed to have lodged there during harvest threshing, formed the basis for these reports. But strong botanical evidence now indicates that Ötzi died in late spring or early summer. Studies by Oeggel of a tiny sample of food residue from Ötzi’s colon have revealed the presence of the pollen of a small tree called hop hornbeam. Strikingly, much of that pollen has retained its cellular contents, which normally decay swiftly. This means that Ötzi might have ingested airborne pollen or drunk water containing freshly shed pollen shortly before he died. The hop hornbeam, which grows up to about 1,200 meters above sea level in the Schnalstal, flow-



THE ICEMAN now lies in a specially built chamber at the South Tyrol Museum of Archaeology in Bolzano, Italy, that keeps him at  $-6$  degrees Celsius and roughly 99 percent humidity.

ers only in late spring and early summer.

As for the sloe found near his body, if Ötzi had been carrying sloes dried like prunes, the drying could have taken place some time before his journey. Small bits of grain also keep indefinitely, and a few scraps could have been carried inadvertently in his clothes for a long period.

## What We Know

MORE THAN 10 YEARS after the discovery of the oldest, best-preserved human body, interpretations about who he was and how he came to rest in a rocky hollow high in the Alps have changed greatly. Just as important, we see that much careful research still needs to be done. The studies of the plant remains—the pollen, seeds, mosses and fungi found both inside and outside the body—have

already disclosed a surprising number of Ötzi’s secrets. We are aware of his omnivorous diet, his intimate knowledge of his surroundings, his southern domicile, his age and state of health, the season of his death, and something of his environment. Perhaps one of the most surprising reinterpretations is that Ötzi did not die on the boulder on which he was found. Rather he had floated there during one of the temporary thaws known to have occurred over the past 5,000 years. The positioning of the body, with the left arm stuck out awkwardly to the right and the right hand trapped under a stone, and the missing epidermis both suggest this conclusion. So does the fact that some of his belongings lay several meters distant, as if they had floated away from the body.

But we do not know and may never know what reason Ötzi had for being at a great altitude in the Alps. And we may never understand exactly how he died. An autopsy would be too destructive to be carried out. In the absence of this kind of proof, we cannot completely exclude the possibility that perhaps Ötzi died elsewhere and was carried to the hollow where the hikers found him 5,000 years later. ■

### MORE TO EXPLORE

**The Omnivorous Tyrolean Iceman: Colon Contents (Meat, Cereals, Pollen, Moss and Whipworm) and Stable Isotope Analyses.** James H. Dickson et al. in *Philosophical Transactions of the Royal Society of London, Series B*, Vol. 355, pages 1843–1849; December 29, 2000.

**INSIGHT: Report of Radiological-Forensic Findings on the Iceman.** Paul Gostner and Eduard Egarter Vigl in *Journal of Archaeological Science*, Vol. 29, No. 3, pages 323–326; March 2002.

**Ötzi’s Last Meals: DNA Analysis of the Intestinal Content of the Neolithic Glacier Mummy from the Alps.** Franco Rollo et al. in *Proceedings of the National Academy of Sciences USA*, Vol. 99, No. 20, pages 12594–12599; October 1, 2002.