BUDAPEST INFERNO – The Secret of the Molnár János Cave

Science documentary, 50’ Full HD, English or Hungarian

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Synopsis

Life on Earth is fed by sunlight - so one could think that the lack of sunlight means no life at all. The truth is just the opposite: a closer look reveals that most dark caves present wildlife in abundance. Recently cave divers and biologists has found previously unknown species under the picturesque capital of Hungary. The Molnár János Cave, the largest underwater thermokarst cave in Europe, has many more secrets to store. Following decided explorers BUDAPEST INFERNO reveals the never before seen underground wonders of Budapest and the deepest secrets of evolution.

00.19	Narrator	The world's deepest cave, the Krubera-Voronya system in the Caucasus is a good example of the surprises one can find deep under the ground. A tiny, almost unremarkable entrance can actually lead to thousands of metres deep.
00.37		Each cave explorer is attracted to the unknown for a different reason.
00.41		Biologists are interested in underground creatures which, sometimes, are reminiscent of legendary monsters.
00.51		Exploring isolated places is a formidable challenge everywhere.
00.58		Cave and karst research is a demanding activity, and often extremely risky.
01.04		On our planet, however, little-known places are only left in the deep sea or underground.
01.15		Cave biologist Gergő Balázs together with Jorge Perez-Moreno in the driving seat, and the daydreaming Dávid Brankovits organised an expedition to the Mexican jungle to learn more about the ecosystem of its caves.
01:40		Approaching a cave entrance is not an easy task and explorers like to carry the most oddball tools to the most unlikely places.
01.56		One of the most interesting questions of cave biology is what connection the inhabitants of absolute darkness have with each other and the outside world; where do they and their nourishment come from?

02.15		In underwater caves, researchers often gather data by analysing the composition of the water. This time, Dávid is using a specially developed, remote-controlled sampler device.
02.31		Most cave ecosystems are nurtured by organic material from above ground. In the almost entirely isolated environment special species evolve which can't be found anywhere else.
02.46		But even the most isolated places usually turn out to be connected to the surface in the end. Analysis of collected animals complements the hydro-chemical tests. But capturing tiny creatures underwater is a rather difficult task.
03.03		Researchers are inclined to believe that discoveries await them in faraway places. But caves are unique in this respect, too. Perhaps the best example of this is the hometown of Dávid and Gergő: Budapest.
03.19	**TITLE**	**BUDAPEST INFERNO** **The Secret of the Molnár János Cave**
04.11		Budapest is known as the 'City of Baths' and as many people also know that the same thermal waters have also created remarkable caves under the city.
04:28		Not many people are aware however that these subterranean passages, under a metropolis of 2 million people, hides secrets which inspire the imagination of scientists all around the world.

04.46		The almost entirely residential district of Rózsadomb or Rose Hill lies right next to the River Danube. Under it we find Hungary's longest cave, the 30 kilometre-long Szépvölgyi Cave System. One of Europe's most beautiful crystal caves can also be found here.
05.04		The József-hegy Cave was discovered during building works in 1984. It took the explorers months to clear the entrance. The descent can still hardly be called comfortable...
05.20		But those who squeeze through the narrow passages and don't shy away from steep descents can admire a spectacle... and not just any spectacle.
05:48		The 67 metre-long 'Kinizsi Railway Station' is one of the biggest hydrothermal chambers in the world. And its size is not the only breathtaking thing about it.
06:00		The walls are covered with fragile formations or speleothems. To protect these crystals, some parts of the cave are closed off even to explorers.
06.16		The passages of the József-hegy Cave were formed hundreds of thousands of years ago. But deep under Rózsadomb there is a cave still in the process of formation. The Molnár János Cave is entirely filled with thermal water. The two caves certainly belong to the same system but the connecting passage has yet to be discovered.
05:43		Gergő Balázs is on his way to the Molnár János Cave, situated across from the Lukács Baths.

06:55		The little lake in front of the cave is visibly full of life. But what does a biologist do in total darkness underground?
07:25		The unusual environment is a serious challenge for scientists, too.
07:33		Thorough preparations precede the exploration; cave diving is a rather dangerous activity.
07:41		In this extreme environment only special creatures can survive.
07.50		Gergő is looking for tiny cave crustaceans. Divers have come across all kinds of cave animals but nobody really knows what species inhabit this cave. With the help of a pump, he is collecting a few specimens for further analysis.
08.13		Scientists are particularly curious about how animals have populated these subterranean passages, and how they can survive in places where no nutrients are visibly available.
08.26		To find answers to these questions, we have to learn more about the processes which shape this cave and its fauna.
08.37		Despite all their equipment, divers can only spend a few hours underwater. But this is enough for them to have a glimpse of times gone by.
08.47		The story of the Molnár János Cave started millions of years ago.
08.53		The walls are decorated by fossils.
09.00		This sea urchin perished around 40 million years ago.

09.07		The clams and sea urchins, of course, did not live in this cave. So how did they get here, if the nearest sea is hundreds of kilometres away? The answer lies in the diagenesis of the limestone which makes up Rózsadomb.
09.22	Anim	Millions of years ago, the area of today's Hungary was covered by sea. The shells of clams, sea urchins, and other animals with calcium carbonate skeletons have survived long after their hosts perished. Over the millennia, the sedimentary shells shattered, cemented, and eventually transformed into limestone. Ultimately, Rózsadomb is made of the residue of similar animals that live in the sea today.
10.04		Four hundred kilometres from Budapest, the Adriatic Sea is a perfect place to meet these live animals.
10.18		In a sea, divers don't need as much equipment as in a cave dive, as long as they don't descend too deep.
10.26		There is also a lot more chance to look around. Nonetheless, it takes time to notice the anemone shrimp hiding in this sea anemone.
10.35		Soles almost entirely blend into the seabed.
10.41		Other fish hide into the shells of perished urchins and are rather mistrustful of curious intruders.
10.50		In fact, this empty-looking seabed is bursting with life.

10.59		Sea urchins play an important role in processing the sediment – and this was already the case when the limestone of today's mountains was formed. Their skeletons, as we could see in the Molnár János Cave, can survive for tens of millions of years.
11.24		Walls at greater depths are home to amazingly beautiful corals.
11.30		The orange moss animals or bryozoa, hiding in cavities, also look familiar: we have seen their fossils, too, in the cave. Their dead skeletons can also be observed in the sea in their original state.
11.51		In the littoral zone, underwater springs bring freshwater into the sea from land.
12.07		The sight of mixing waters is also familiar from the Molnár János Cave. Moreover, the cave itself was widened to a passable size by the corrosive force of mixing waters.
12.21		The cupolas on the walls are the most visible evidence of the so-called mixing corrosion.
12:29		During millions of years, movements of the Earth's crust cracked fissures into the limestone. The upsurging thermal water enlarged these cracks into subterranean passages, precisely because of the corrosive force of mixing waters. Thus, the caves of the Buda Thermal Karst were not formed by descending rain water but rising thermal water. The water later receded and some of the passages dried out.

13.11		The cave forming effect of thermal water is most spectacular in the József-hegy Cave of Rózsadomb.
13.19		Gergő and other cavers are squeeze through the narrow entrance zone to learn more about the formation of the cave system.
13.28		They are accompanied by one of the discoverers, geologist Dr. Szabolcs Leél-Őssy a distinguished cave expert.
13.43		As they get closer to the Kinizsi Railway Station the character of passages changes.
13.51		Szabolcs has been to the cave hundreds of times and knows all its secrets.
14.02		A good half a million years ago, this part of Budapest and the Buda Hills looked entirely different. Not only was the Molnár János Cave entirely filled with thermal water but so was the József-hegy Cave, a hundred metres above it.
14.17	Szabolcs	*First these thin layers of black and rusty-coloured, manganese and iron layers covered the rock – it's the product of bacteria that were living in the warm water.*
14.30	Narrator	If we look into the water of today's thermal springs, we can observe and collect these bacteria sites, living not far below the surface.

14.38	Szabolcs	*When the water levels dropped further, carbon-dioxide released through the water surface. So called cave rafts precipitated on top of the karst water, and a few centimetre thick calcite layer wrapped the rock everywhere.*
14.53		*When the water levels descended even further, the vapour mixed with infiltrating waters and restarted dissolving the limestone content of the rock. As it trickled down towards the lake, the water warmed up again and these coralloids, and beautiful aragonite crystalline needles on top of the coralloid crystals, precipitated by evaporation.*
15.18		*Particular crystals are 1-2 centimetres long and are forming clusters on top of each other in all directions.*
15.27	Gergő	*And the ice cream scoops over there?*
15.29	Szabolcs	*Those are normal dripstones which are growing slowly and have reached their current, 5-6 centimetre thickness in a few thousand years.*
15.38	Gergő	*All right but why is it pink?*
15.40	Szabolcs	*The water dissolves a little iron-oxide: if there is very little of it, the colour becomes pinkish. If a little more, it becomes brownish but there is also a blood red, dark variety.*

15.57	Narrator	In the Molnár János Cave we can't see such beautiful formations as the cave is still filled with water which also makes exploration rather difficult.
16.14		Only the most experienced divers can explore underwater caves.
16.20		Attila Hosszú and László Müllner are key figures in the recent activities taking place in the Molnár János Cave.
16.29		Before the dive, they check every piece of equipment. Underwater, the smallest mistake can have fatal consequences.
16:39		The purpose of today's dive is to install the guideline in a newly discovered passage. Such complicated operations need thorough planning.
16.53	Attila	*Where did we left off the last time?*
16.55	Laci	*We were here in the Sajti, where that line comes in from 50 metres. There is the spool, approximately.*
17.02	Attila	*We would need to take it forward until this point.*
17.05	Laci	*So I'm rolling the roll and you're drilling the fix. I'll tie to it to have an escape route in case of anything...*
17.11	Attila	*Fine, so you are bringing the rope until here anyway, and I start drilling the fix points that need drilling, and you tie up the ones that need tying up.*

17.18	Narrator	At different depths, divers inhale different gas mixtures to make the dive more secure. When planning the composition of breathing gases, potential emergency situations also have to be considered.
17.31	Attila	*This is our way out, if we manage to fix the rope. If not, then we take this escape route here...*
17.41	Laci	*OK. Then let's analyse our cylinders and we are a go.*
17.45	Narrator	They are analysing the composition of the breathing gases just before the dive. One sip of the wrong gas at the wrong depth is enough for the diver to lose consciousness.
18:14		Apart from the many cylinders, they have to carry the tools needed to fix the rope, so they are using underwater scooters. When everything is in place, they can finally set off to explore the unknown depths.
19.17		Divers communicate with hand signals while underwater. Before continuing they have a last chat; everything has to be right. Deep down in the cave they have only each other to count on.
20.13		When they arrive at the new part of the cave, they put down the scooters. They have come far from the safety of the surface but their real task is only just beginning. With this pneumatic drill, they can fix stands anywhere.

20.34		The new rope begins where the old one ends. This way, divers can always find their way out.
20.45		They have to move around carefully while swimming. A single thrust with their fins could stir up the fine sediment, and reduce visibility so they wouldn’t be able to finish their task.
21.08		The rope has to be fixed at a regular distance to ensure that it always remains tight and leads in the right direction.
21.34		The air bubbles released from the pneumatic drill stir up the sediment. Only a screw is left to be fastened and the fix point is ready.
21.50		The tightened rope will be a solid guideline for the divers. Visibility could drop so much that the explorers would not be able to find their way out without it.
22.05		It also matters in which direction the exit is to be found. So divers attach arrows to the rope which always point towards the nearest exit.
22.23		During the last few decades, 6 kilometres of new passages have been discovered, and explorers have reached the depth of 100 metres.
22.33		Today, everything went according to plan, and quite a few metres of fixed rope were installed.
22.44		But the dive is not yet over. To avoid decompression sickness, divers have to make lengthy decompression stops when ascending. During a deeper dive these may take several hours. But the work done today has an additional benefit: the guideline ropes also help in the surveying of the cave.

23.07		Sections of the rope can easily be measured. In the knowledge of the length, direction, and gradient of rope sections, the spatial model of the guideline ropes can be built. This so-called polygon follows the cave passages, as the rope usually runs parallel with the walls.
23.29		Following further measuring, walls can also be added to the model. Making a precise map however needs a lot of practice, and is very time consuming.
23.48		Members of the mapping team, Péter Zsoldos and Viktor Pap have worked on the Molnár János Cave for years.
23.57		They are measuring the lengths of each rope section with a regular tape measure because laser measures simply don’t work in the water.
24.09		It’s important that they read the measurement values precisely: errors add up in the polygon and may significantly distort the map.
24.33		After the length of a rope section, its direction has to be specified.
24.47		Many people use digital compasses but some divers swear by the traditional suspension compass.
25.04		The measures are recorded on whiteboards and then processed by computers.
25.16		From measuring the depths of each end of a rope section, its inclination can be calculated. Thus, all data is available to make the polygon.

25.44		The survey not only helps with orientation and planning the dive. The map provides useful information for geologists, keen to understand the secrets of cave formation, and explorers searching for unknown passages.
25.59		The map has an additional benefit: it helps to imagine the unimaginable. By integrating the model with a street map, one can clearly see the real size and extension of this underground wonderland.
26.14		A piece of rope left in an old mapping point is an important meeting point for the permanent residents of the cave, too.
26.24		Following years of exploration by cave divers, biologists can eventually study these cave animals more thoroughly.
26.39		But what kind of animals actually live in this cave? And how do they stay alive in this rather hostile environment? The answer is to be found in the rigorous study of the collected specimens.
26.56		Gergő places each crustacean captured into tiny vials and conserves them in alcohol.
27.07		The primary examination takes place at the Department of Systematic Zoology and Ecology of Eötvös Loránd University of Budapest.
27.36		The specimens have to be carefully prepared before they can be examined. Defining the species of these tiny animals needs great precision.

27.55		To prepare the permanent slides, the exoskeletons of the animals have to be cleared of organic materials in steaming potassium hydroxide bath.
28.15		As cave animals are typically colourless, microscopic details are difficult to observe. By using a suitable dye, even the tiniest parts become distinguishable. When defining species, the most subtle details matter.
28.50		Every appendage has to be made ready for examination. The lengthy process requires some dexterity.
29.11		The prepared slide will be catalogued so that it can be compared and contrasted with the results of other studies.
29.23		Some of the collected animals won't end up under the microscope. Geneticists of Florida International University will study them.
29.36		Through the lenses of an optical microscope, the smallest details that differentiate species can be observed.
29.53		Two of the crustacean specimens collected in the Molnár János Cave appear to be previously unknown species.
30.05		For absolute certainty genetic tests are necessary.
30.24		Jorge Luis Perez-Moreno is a geneticist at Florida International University in Miami, Florida. This is one of the leading laboratories in the genetic study of crustaceans.
30.39		They are looking for several answers in the Budapest samples.

30.44		Genetic data support the hypothesis: these are indeed two new species. But researchers also want to know how these species ended up in the cave, and how they are related to other species found elsewhere.
31.00		Genetic similarities and differences provide clues about the affinities with other species. The PCR machine replicated DNA fragments can provide answers to several questions.
31.14		Discovering two new species in the middle of a metropolis is quite unusual. But there is something else. The most exciting results are linked to an already known species. It turns out that the water louse found in the cave don’t interbreed with their above ground cousins. This means that we are witnessing the evolution of a brand new species.
31.43		Visitors to the Hungarian Natural History Museum of Budapest are often unaware that beyond the exhibition space, serious scientific research is underway.
31.59		Dr. Dorottya Angyal is a zoologist at the museum. Together with Gergő Balázs, she is scientifically describing the two new species.
32.15		This time she’s applying a very different method compared to those in Miami: she’s drawing the characteristics of the species by hand.

32.33		Thanks to a clever optical system, she can see the slide and the drawing paper at the same time. This way, she can visualise characteristics which neither digital technology, nor genetic analysis can, as only the human brain is capable of making the necessary distinctions.
32.57		Applying old and new methods are equally important. Similar looking creatures are often found to belong to different species, while animals belonging to the same species occasionally look very different because of their diverse habitats.
33.15		Water louse, for instance, can be found in several caves and while their appearance may vary, they don't always evolve into new species. For that to happen, the genetic mixing of different populations must stop. According to data, cave water louse in the Molnár János Cave become isolated from above ground populations 110 thousand years ago. This coincides with an important glacial period.
33.43		The split therefore was probably caused by the temporary sheer hostility of the outside world. Those specimens that had withdrawn to the cave could start their separate evolution. Adapting to the subterranean environment, they began to lose their colour and redundant eyes, while their sensory tentacles and legs expanded.

34.19		One thing is certain: the ice age is over and water louse can manage outside as well.
34.28		In the sunlit lake, they find ample nourishment which is visible from their well-functioning digestive systems.
34.37		But what do their subterranean cousins eat? Thermal water is from deep inside the Earth's crust, and organic materials from above ground can hardly reach the cave. For an answer, we have to learn more about how animals find nourishment.
35.01		Rainforests are the richest habitats in the world. Trees using the Sun's energy produce organic materials from carbon-dioxide and water, which later serve as nourishment for numerous animals.
35.24		Leaf-cutter ants take advantage of this: they cut the leaves and carry them home to cultivate nutritious fungi on them.
35.33		In the rainforest, every animal lives off the nourishment produced by plants. And this is true of the vast majority of animals on Earth: almost all depend for their daily sustenance on organic materials produced by photosynthesis.
35.55		Even notorious carnivores do this: they just wait before somebody else processes the plants for them first...
36.09		Apart from rainforests, there are other ecosystems with a similar abundance of species. Tropical coral reefs are perhaps the most spectacular ones.

36.40		We don’t find huge underwater plants but the invisible mass of microscopic algae use the Sun’s energy exactly the same way as trees in the rainforest.
36.57		In the end, fish feeding on corals use the products of photosynthesis exactly like terrestrial animals. The whole system is sustained by sunlight.
37.13		Naturally, there are animals which feed on others here, too. Sharks, which are on top of the food chain, are known to be the most efficient predators of the seas.
37.27		But how does this system work deeper in the water where there is no sunlight and photosynthesis?
37.54		Traditional scuba diving gear limits sea explorations to minus 200 metres. To go deeper than this, one has to use a submarine.
38.16	Pilot	*“This ... ... at one-zero metres, we're going down.”*
38.21	Narrator	Cameraman Zsolt Sásdi and photographer Dániel Selmeczi are about to photograph the empire of the deep, off Cocos Island in Costa Rica.
38.34	Pilot	*“We're going the way to 200 metres on the platform then we go...”*
38.46	Narrator	Beyond the depth of 200 metres total darkness awaits them. For navigation they are entirely dependent on the onboard computers.

38.58		Even at this depth the upper world has an obvious effect on animals.
39.06		This hooked shark could feel these effects more than skin-deep.
39.15		The palm leaf lying on the sea bed demonstrates that organic matter can get even to deeper waters from the surface, providing nourishment to underwater animals.
39.32		Despite total darkness plenty of animals live here. Even if indirectly, however, they all survive because of sunlight.
39.43		This submarine can only dive to the depth of 300 metres. Already at this depth there are peculiar animals which look as if they were from a different planet.
39.55		Deeper waters are explored by remote-operated vehicles.
40.06		The robot of the MARUM institute of the University of Bremen is able to descend to thousands of metres deep.
40.22		Animal communities around so-called ‘black smokers’ sort of thermal vents at thousands of metres deep were only discovered at the end of the 20th century.
40.35		These communities are often entirely independent of sunlight as their food web doesn’t rely on photosynthesis. Organic matter is produced by bacteria through a chemical process.

40.47		The outcome of the so-called chemosynthesis is then used by many animals. Thus, deep-sea vents can sustain fully-fledged ecosystems, even without sunlight.
41.03		Chemosynthesis is known from caves too, but it only rarely plays a defining role in the food web. Only a few caves are known worldwide where this is the case. It has occurred to researchers that the Molnár János Cave could be one of them.
41.21		Dávid Brankovits, a researcher at the Texas University of Agriculture and Mechanics, is an expert in isolated ecosystems. He primarily studies Mexican caves but when he heard about the discovery of a peculiar animal community in the Molnár János Cave, he joined the research in his hometown.
41.41		He decided to thoroughly examine the ecological features of the Molnár János Cave.
41.51		Dávid will take water samples for chemical analysis. Gergő will collect crustaceans again for isotope-ratio analysis of their organic composition, which will shed light on where their nutrients came from.
42.09		Sample collecting needs as much preparations as an exploratory dive: a mistake in the plan can risk more than the research results.

42.27	Dávid	*If we want to know what the energy sources of these cave animals are, where they get their nutrients from, then the stable isotope analyses of carbon and nitrogen can show that really nicely.*
42.47	Gergő	*Good... then what we should do is that when we arrive at a place you take a sample before anything.*
42.56	Dávid	*Yes, that would be ideal: water sample first, and then we can go chasing animals.*
43.10	Narrator	Once they attach all the necessary gear to themselves, they leave for the water.
43.19		Thanks to decades of exploratory work in the cave, entering the water is rather comfortable.
43.26		But down there they will have a difficult task. Animals can't be found everywhere in the cave. They frequent zones where the thermal waters of different temperatures mix.
43.43		Their time is also limited: once they have used a third of their breathing gas, they have to make their way out.
43.56		This is why it's so important to choose the locations precisely. Nevertheless, it's difficult to find just a few millimetre-long animals even in known habitats.
44.49		Thanks to underway explorations, the most important mixing zones are already known.
44.59		Dávid is using a lockable syringe to collect water samples for analysis.

45.15		The researchers descend deeper and deeper: the more diverse the locations of their samples, the higher their chances to verify their hypotheses.
45.32		Luckily, they bump into creatures at places where they were never seen before.
45.38		It’s important to have the appropriate number of specimens from each species because different species follow varied nourishment strategies.
45.48		The sample trap of the pump is transparent so scientists can verify on-site whether they have captured the right species.
46.06		Dávid has been studying the animals of the Molnár János Cave in various laboratories for months but this is the first time he meets them live.
46.21		After precisely recording the location of each sample, they make their way out of the cave.
46.31		Solving the puzzles of darkness may make a great contribution to science. According to certain theories, chemosynthesis provided energy for the very first organisms at the beginning of life on Earth.
46.48		If it turns out that similar mechanisms exist in the middle of a metropolis, researchers can study the characteristics of such systems at a more accessible location than in the deep sea.

47.04		After returning to the surface, samples have to be secured as soon as possible. Samples destined for isotopic study mustn't be contaminated with organic matter from above ground, lest this leads to false results.
47.19		What the data will unearth remains to be seen.
47.24		Dávid will soon return to Texas, and the isotopic studies will take place in a laboratory in Switzerland.
47.33		They hope that the Mexico-method will work for these samples, too.
47.48		Recently, biologists found a snail species in the Molnár János Cave which demonstrates that a complex ecosystem exists there. Both the snail and the cave crustaceans feed on bacteria.
48.09		The cave was named after its first explorer, János Molnár. The 19th century chemist never saw the cave's passages. He proved its existence solely by hydro-chemical analysis. Almost a 150 years later, scientists are trying to unearth the cave's secrets in laboratories just like he did.
48.43		As the explorations advance, more and more secrets of the Molnár János Cave come to light.
48.51		One thing is certain: in this city of 2 million, people of Budapest walk on unique wonders.
49.02		But the proximity of the city also impacts the caves. Analyses have shown traces of contamination in the cave from the municipal sewage system.

49.21		The findings have also caught the attention of the international scientific community. Decades-long explorations however do not end here. Researchers hope that by publishing their findings, they will contribute to the protection of the cave, too.
49.45	END CREDITS	
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		Devon Karst Research Society
		DiveLabs Diving Equipment
		Duna Ipoly National Park Headquarters
		Galathea Diving Center
		Inverse Everest Expedition
		MJ Cave Diving Center
		MyActionCam
		Red Sea Boats Holidays
		Saser Productions
		Undersea Hunter Group

		National Media and Infocommunications Authority, Hungary
50.35	END	