STEPHEN HAWKING'S TIME MACHINE by Alfred Johnson

In an article in the Daily Mail this week, British cosmologist Stephen Hawking outlined not one, but three, theoretically realistic ideas for traveling through time, one of which he says is even practical.

The fourth dimension
First, though, you have to get your head around the notion that time is a dimension, just like width, height and length.

Hawking uses the example of driving in your car: You go forward. That's one direction. You turn left or right, that's a second. You journey up a mountain road, that's a third. The fourth dimension is time.

"Time travel movies often feature a vast, energy-hungry machine. **The machine creates a path through the fourth dimension**
, a tunnel through time. A time traveler, a brave, perhaps foolhardy individual, prepared for who knows what, steps into the time tunnel and emerges who knows when. The concept may be far-fetched, and the reality may be very different from this, but the idea itself is not so crazy," Hawking writes.

The laws of physics actually accommodate the notion of time travel, through portals known as wormholes.

"The truth is wormholes are all around us, only they're too small to see. They occur in nooks and crannies in space and time," Hawking writes. "Nothing is flat or solid. If you look closely enough at anything you'll find holes and wrinkles in it. It's a basic physical principle, and it even applies to time. Even something as smooth as a pool ball has tiny crevices, wrinkles and voids.

Quantum foam and tiny wormholes

"Down at the smallest of scales, smaller even than molecules, smaller than atoms, we get to a place called the quantum foam. This is where wormholes exist. Tiny tunnels or shortcuts through space and time constantly form, disappear, and reform within this quantum world. And they actually link two separate places and two different times."

The tunnels, unfortunately, are far too small for people to pass through — just a billion-trillion-trillionths of a centimeter -- but physicists believe it may be possible to catch a wormhole and make it big enough for people, or spaceships, to enter, Hawking writes.

"Theoretically, a time tunnel or wormhole could do even more than take us to other planets. If both ends were in the same place, and separated by time instead of distance, a ship could fly in and come out still near Earth, but in the distant past. Maybe dinosaurs would witness the ship coming in for a landing," Hawking writes.

Ultimately, scientists may find that only travel into the future is possible, as the laws of nature may make travel to the past impossible so the relationship between cause and effect is maintained. For example, if you could travel in the past and do something that prevents yourself from being born, how could you exist in the future to travel back in time?

Time as a flowing river

Hawking suspects radiation feedback would collapse any wormholes scientists managed to expand to useable sizes, rendering them useless for actual travel. But there's another way — navigating the variable rivers of time.

"Time flows like a river and it seems as if each of us is carried relentlessly along by time's current. But time is like a river in another way. It flows at different speeds in different places, and that is the key to traveling into the future," Hawking writes.

Albert Einstein first proposed this idea 100 years ago that there should be places where time

slows down, and others where time speeds up, notes Hawking. "He was absolutely right."

The proof, says Hawking, lies in the Global Positioning System satellite network, which in addition to helping us navigate on Earth, reveals that time runs faster in space.

"Inside each spacecraft is a very precise clock. But despite being so accurate, they all gain around a third of a billionth of a second every day. The system has to correct for the drift, otherwise that tiny difference would upset the whole system, causing every GPS device on Earth to go out by about six miles a day," Hawking writes.

The clocks aren't faulty — it's the pull of Earth that's to blame.

"Einstein realized that matter drags on time and slows it down like the slow part of a river. The heavier the object, the more it drags on time," Hawking writes. "And this startling reality is what opens the door to the possibility of time travel to the future."

Black holes and flying at the speed of light

The keys to time travel are black holes, objects so dense that not even light can escape their gravitational grip.

"A black hole ... has a dramatic effect on time, slowing it down far more than anything else in the galaxy. That makes it a natural time machine," Hawking writes.

Here's how it might work:

Imagine a spaceship orbiting the super-massive black hole at the center of the Milky Way galaxy, 26,000 light years away. From Earth, it would look like the ship is making one orbit every 16 minutes, Hawking writes.

"But for the brave people on board, close to this massive object, time would be slowed down," Hawking writes. "For every 16-minute orbit, they'd only experience eight minutes of time."

If they circled for five years, local time, 10 years would have passed back on Earth.

This scenario doesn't produce the paradoxes inherent in wormhole travel, but it's still pretty impractical, Hawking acknowledges.

But there's one more possibility: traveling super fast.

"This is due to another strange fact about the universe," writes Hawking — the cosmic speed limit: 186,000 miles per second, or the speed of light.

"Nothing can exceed that speed. It's one of the best established principles in science," writes Hawking, but "believe it or not, traveling at near the speed of light transports you to the future."

"Imagine a track that goes right around Earth, a track for a super-fast train. Onboard are passengers with a one-way ticket to the future. The train begins to accelerate, faster and faster. Soon it's circling the Earth over and over again.

"To approach the speed of light means circling the Earth seven times a second. But no matter how much power the train has, it can never quite reach the speed of light, since the laws of physics forbid it.

"Instead, let's say it gets close," writes Hawking. "Something extraordinary happens: Time starts flowing slowly on board relative to the rest of the world, just like near the black hole, only more so. Everything on the train is in slow motion."

Speed of light protection
This happens to protect the cosmic speed limit, Hawking said. Here's why:

Say there's a child running forward up the train. "Her forward speed is added to the speed of the train, so couldn't she break the speed limit simply by accident? The answer is no," writes Hawking. "The laws of nature prevent the possibility by slowing down time onboard. Now she can't run fast enough to break the limit. Time will always slow down just enough to protect the speed limit."

This is the essence of why time travel into the future is possible.

"Imagine that the train left the station on January 1, 2050. It circles Earth over and over again for 100 years before finally coming to a halt on New Year's Day, 2150. The passengers will have only lived one week because time is slowed down that much inside the train. When they got out they'd find a very different world from the one they'd left. In one week they'd have travelled 100 years into the future," Hawking writes.

Right now, the fastest motion on Earth is taking place in the circular tunnels of the world's largest particle accelerator at CERN, in Geneva.

"When the power is turned on (particles) accelerate from zero to 60,000 mph in a fraction of a second. Increase the power and the particles go faster and faster, until they're whizzing around the tunnel 11,000 times a second, which is almost the speed of light. But just like the train, they never quite reach that ultimate speed. They can only get to 99.99 per cent of the limit. When that happens, they too start to travel in time. We know this because of some extremely short-lived particles, called pimesons. Ordinarily, they disintegrate after just 25 billionths of a second. But when they are accelerated to near-light speed they last 30 times longer."

To accelerate humans to that speed, we'll need to be in space, concludes Hawking, noting that so far, the fastest that people have traveled is 25,000 mph aboard Apollo 10.

"To travel in time we'll have to go more than 2,000 times faster (than Apollo 10). And to do that

we'd need a much bigger ship, a truly enormous machinebig enough to carry a huge amount of fuel, enough to accelerate it to nearly the speed of light. Getting to just beneath the cosmic speed limit would require six whole years at full power.

"We could, in theory, travel extraordinary distances within one lifetime," Hawking writes. "A trip to the edge of the galaxy would take just 80 years."