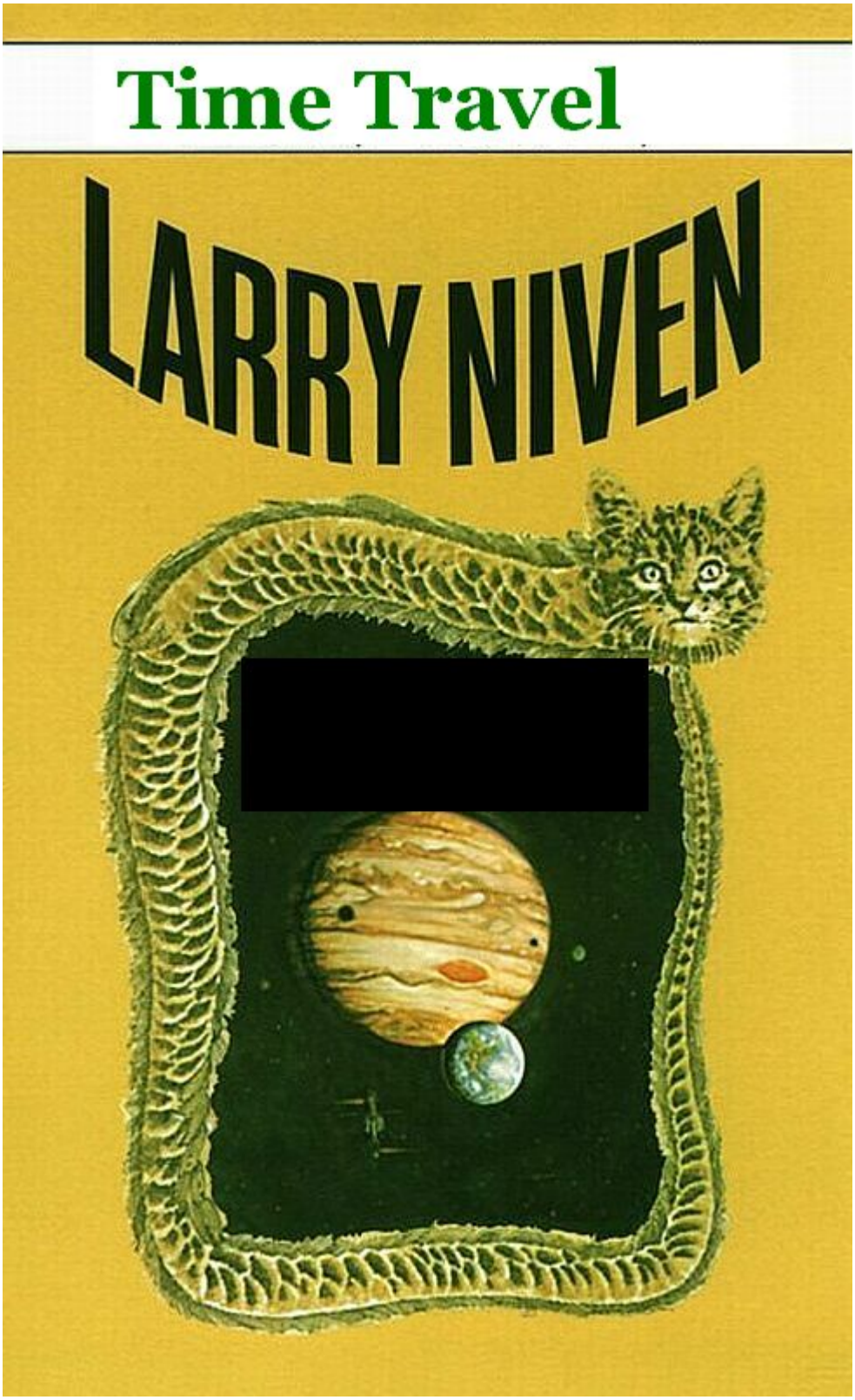

Larry Niven - THE THEORY AND PRACTICE OF TIME TRAVEL Speculate: (2) To ponder a subject in its different aspects and relations; meditate; esp. to theorise from conjectures without sufficient evidence. -Webster's New Collegiate Dictionary, 1959 Once upon a time a man was given three wishes. He blew the first two, getting himself in such deep trouble that if he let either wish

stand, he would suffer terribly. Now desperate, he cried, "I wish I'd never had a fairy godmother!" And the past healed to cancel both wishes. The first time-travel story was a fairy tale-here drastically condensed. Its theme is buried deep in the literature. L. Frank Baum used it in THE WONDERFUL LAND OF OZ. Cabell borrowed it for THE SILVER STALLION. Traditionally the protagonist may change the past without actually moving backward in time. H. G. Wells, one of the fathers of modern science fiction, also fathered the time traveling vehicle. This may be the reason Well's spiritual sons tend to treat time travel as science fiction rather than fantasy. But Wells wrote only of travel into the future. He missed the Grandfather Paradox and all the other derivative paradoxes of travel into the past. His time machine was a mere vehicle, no more remarkable than the gravity shielding material, Cavorite.* (*Both were mere philosophical vehicles. Wells liked to preach.) Wells also missed the most important aspect of time travel: wish fulfillment. When a child prays, "Please, God, make it didn't happen," he is inventing time travel in its essence. (He will probably give up the idea when he learns good English. More about that later.) The prime purpose of time travel is to change the past; and the prime danger is that the Traveler might change the past. The man who first thought of travel into the past combined the Wells machine with the fairy tale to produce time travel in its present form. Time machines come in many forms. Well's man-carrying vehicle was as open as a bicycle seat, with a magnificent view of time flashing past. Poul Anderson's standard issue time Patrol vehicle could do anything Well's could, and fly too. More restricted machines may travel only into the future, or may send only subatomic particles into the past, or may be restricted to things even less substantial: thoughts, dreams, emotional states. Others may move only in quantum jumps of a million or sixty million years. A writer who puts severe limits on his time machine, is generally limiting its ability to change the past in order to make his story less incredible. THE GRANDFATHER PARADOX is basic to any discussion of time travel. It runs as follows: At the age of eighty your grandfather invents a time machine. You hate the old man, so you steal the machine and take it sixty years back into the past and kill him. How can they suspect you? But you've killed him before he can meet your grandmother. Thus you were never born. He didn't get a chance to build the time machine either. But then you can't have killed him. Thus he may sire your father, who may sire you. Later there will be a time machine... You and the machine both do and do not exist Paradox! In general we will call any such interference with the past, especially self-cancelling interference, a Grandfather Paradox. Travel into the past violates certain of what we regard as laws of nature. (1) A vehicle which travels from the thirtieth century AD to the twentieth, may be regarded as appearing from nowhere. Thus it violates the law of conservation of matter. If the vehicle carries a power source of any kind, it also violates conservation of energy...a quibble, as they are both the same law these days. To say that an equivalent tonnage of matter disappears a thousand years later is no answer. For ten centuries there was an extra time machine around. But things are even worse if a Grandfather Paradox is involved. One can imagine a centuries-old time machine resting in a museum, inside a glass-and-steel case made from the glass and the steel which would have been used to build the time machine, if anyone had gone ahead and built that time machine, which nobody did, because of interference with the past via that same time machine. (2) If one cannot send matter through time, perhaps one can send signals-information. But even this violates conservation of energy. Any signal involves energy in some form. Furthermore, relativity laws state that information cannot travel faster than c, the velocity of light in a vacuum. A signal traveling back through time travels faster than infinity! (3) Physical time travel clearly violates any law of motion, as motion always relates to time. This affects conservation of momentum, statements about kinetic energy, and even the law of gravity. Anybody's law of gravity. (4) What about drawing information from the future? If precognition and prophecy are only very accurate guesswork by the subconscious mind, then no laws are violated. But if

precognition really has something to do with time- I cite the Heisenberg Principle. One cannot observe something without affecting it. If one observes the future, there must be an energy exchange of some kind. But that implies that the future one is observing is the future; that it already exists; that information is flowing into the past. I've demonstrated that this violates relativity and conservation of energy. It also involves a Grandfather Paradox, if information drawn from one future is used to create another. And if the information can't be used to change the future, then what good is it? What was that about the stock market? (5) Travel into the future is no more difficult than suspended animation and a good, durable time capsule. But you can't go home without traveling into the past. Does any of this seem like nitpicking? Sure it Is. Are we to regard the laws of relativity and conservation as sacred, never to be broken, nor even bent by exceptions? Heaven forbid. But time travel violates laws more basic than conservation laws. Our belief in laws of any kind presupposes a belief in cause and effect. Time travel reverses cause and effect. With a Grandfather Paradox operating, the effect, coming before the cause, may cause the cause never to come into effect, with results which are not even self consistent Characters in time-travel stories often complain that English isn't really built to handle time travel. The tenses get all fouled up. We in the trade call this problem Excedrin Headache number V -3.14159. To show it in action, I'd like to quote from one of my own stories, BIRD IN THE HAND. The characters have done catastrophic damage to the past, and are discussing how to repair it. "Maybe we can go around you." Svetz hesitated, then plunged in. "Zeera, try this. Send me back to an hour before the earlier Zeera arrives. Ford's automobile won't have disappeared yet. I'll duplicate it, duplicate the duplicate, take the reversed duplicate and the original past you in the big extension cage. That leaves you to destroy the duplicate instead of the original. I reappear after you've gone, leave the original automobile for Ford, and come back here with the reversed duplicate. How's that?" "It sounded great Would you mind going through it again?" "Let's see. I go back to-" This was less of a digression than it seemed. The English language can't handle time travel. We conclude that the ancestors who made our language didn't have minds equipped to handle tithe travel. Naturally we don't either; for our thinking is too dependent on our language. As far as I know, no language has tenses equipped to handle time travel. No language on Earth. Yet. But then, no language was ever equipped to handle lasers, television, or spaceflight until lasers, television, and spaceflight were developed. Then the words followed. If time travel were thrust upon us, would we develop a language to handle it? We'd need a basic past tense, an altered past tense, a potential past tense (might have been), an altered future tense, an excised future tense (for a future that can no longer happen), a home base present tense, a present-of-the-moment tense, an enclosed present tense (for use while the vehicle is moving through time), a future past tense ("I'll meet you at the bombing of Pearl Harbor in half an hour."), a past future tense ("Just a souvenir I picked up ten million years from now"), and many more. We'd need at least two directions of time flow: sequential personal time, and universal time, with a complete set of tenses for each. We'd need pronouns to distinguish [you of the past] from [you of the future] and [you of the present]. After all, the three of you might all be sitting around the same table someday. Meanwhile (if, God willing, the word still has meaning), time travel must be considered fantasy. It violates too many of the laws of physics and reason to be thought otherwise. But it's a form of fantasy superbly suited to games of logic. The temptation to work out a self-consistent set of laws for time travel must be enormous. So many writers have tried it! Let's look at some of the more popular possibilities: DEFENSE OF TIME TRAVEL #1: Assume that (1) One can travel only into the future. (2) The universe is cyclic in time, repeating itself over and over. This works! All you've got to do is go into the future past the Big Collapse when the universe falls in on itself, through the Big Bang when it explodes again, and keep going until you

reach the area of the past you're looking for. Then you murder Hitler in 1920, or use the H-bomb on the damyankees at Appomatox, or whatever your daydream is. There is no Grandfather Paradox. You merely get a new future. True, the next version of you will not make the trip. You've eliminated his motive. Thus on the next cycle the damyankees will win the Civil War, Hitler will lead Germany into WWII, and so forth. But you've merely introduced a double cycle. There is no paradox. Further, your time machine need be nothing more than an EXTREMELY durable time capsule. OBJECTIONS: Three. First, some people don't believe in cyclic time. (I don't.) Second, locating the proper era is a nontrivial problem when you've got the whole lifetime of the universe to search in. You'd be lucky to find any section of human history. Third, removing your time capsule from the reaction of the Big Bang could change the final configuration of matter, giving an entirely different history. DEFENSE OF TIME TRAVEL #II: Known as the theory of multiple time tracks. Let there be a myriad of realities, of universes. For every decision made by any form of life, let it be made both ways; or in all possible wars if there are more then two choices. Let universes be created with every choice. Then conservation of matter and energy holds only for the universe of universes. One can move time machines from one universe to another. You've got to admit it's flamboyant! You still can't visit the past. But you can find a universe where things happened more slowly; where Napoleon is about to fight Waterloo, or Nero is about to ascend the throne. Or, instead of changing the past, you need only seek out the universe where the past you want is the one that happened. The universe you want unquestionably exists. (Though you may search a long, weary time before you find it.) Ersatz time travel becomes a special case of sidewise-in-time travel, travel between multiple time tracks. The what-if story has fascinated many writers. Even O. Henry wrote at least one. From our viewpoint, sidewise-in-time travel solves conservation laws, Grandfather Paradox, everything. I hate sidewise-in-time travel stories. Let me show you why. First, they're too easy to write. You don't need a brain to write alternate-world stories. You need a good history text. In the second place…did you ever sweat over a decision? Think about one that really gave you trouble, because you knew that what you did would affect you for the rest of your life. Now imagine that for every way you could have jumped, one of you in one universe did jump that way. Now don't you feel silly? Sweating over something so trivial, when you were going to take all the choices anyway. And if you think that's silly, consider that one of you still can't decide... In the third place, probability doesn't support the theory of alternate time tracks. There are six ways a die can fall, right? Which makes thirty-six ways that two dice can fall, including six ways to get a seven. Each way the dice can fall determines one universe. Then the chance of your ending in each of the thirty-six universes is one in thirty-six, right? Then it doesn't matter if the dice are loaded. One chance in thirty-six, exactly, is the odds for each way the dice can fall. One chance in six, exactly, of getting a seven. Experience, however, shows that it does matter if the dice are loaded. DEFENSE OF TIME TRAVEL #III: The idea of reversing the flow of time isn't nearly as silly as it sounds. I quote from an article in the October 1969 issue of Scientific American, "EXPERIMENTS IN TIME REVERSAL," by Oliver E. Overseth. "All of us vividly recognise the way time flows; we take considerable comfort, for example, in our confidence that the carefully arranged marriage of gin and vermouth is not going to be suddenly annulled in our glass, leaving us with two layers of warm liquid and a lump of ice. It is a curious fact, however, that the laws that provide the basis for our understanding of fundamental physical processes (and presumably biological processes as well) do not favor one direction of time's arrow over another. They would represent the world just as well if time were flowing backward instead of forward and martinis were coming apart rather than being created." Is the universe really invarient under time reversal? Many physicists think not. Overseth and his partner Roth spent almost two years looking for a case in subatomic physics in which invarience under time

reversal is not preserved. They knew exactly what they were looking for. They were watching (via some very indirect instruments) the decay of a lambda particle into a proton plus a pi meson. The anomaly would have been a nonzero value for the beta component of the spin of the proton. The point is that they failed to find what they were looking for. There have been many such experiments in recent years, and none have been successful. At the subatomic level, one cannot tell whether time is running backward or forward. Could a determined man reach the past by reversing himself in time and waiting for last year to happen again? Present theory says that he would reverse both the spin and the charge of every subatomic particle in his body. The charge reversal converts the whole mass to antimatter. BOOM! Less dramatically, there is conservation of mass/energy. Reverse the direction of travel in time of a human body, and to any physicist it would look like two people have vanished. Clearly this is illegal. We can't do it that way. We might more successfully reverse a man's viewpoint: send his mind backward in time. If there is really no difference between past and future, except in attitude, then it should be possible. But the traveler risks his memory healing to a tabula rasa, a blank slate. When he reaches his target date he might not remember what to do about it. For there is still entropy: the tendency to disorder in the universe, and the most obvious effect of moving "forward" in time. Entropy is not obvious where few reactions are involved, as in the motion of the planets, or as when a lambda parlicle breaks down. But the mushroom cloud left by a hydrogen bomb is difficult to return to its metal case. That's entropy. Any specialist in geriatric medicine knows about entropy. Let's try something less ambitious. Suppose we found a clump of particles already moving backward in time. (Exactly what Roth and Overseth and their brethren might find in their experiments, if time-reversal turns out to be valid. Though most expect to find just the opposite.) Now we write messages on that clump. Simple messages. "Blue Ben in the sixth, 4/4/72." But from our viewpoint, we start by finding a message and end by erasing it! And if it went wrong…We find a message: "Blue Ben in the sixth, 4/4/72." We bet on him, and he loses. Now what? Can we unwrite a different message? Or just refuse to erase it at all? But if it did work, we could make a fortune. And it violates no known physical laws! Practically. Meanwhile, Roth and Overseth and a number of others are all convinced that there must be exceptions to the symmetry of time. If they find just one, it's all over. DEFENSE OF TIME TRAVEL #IV: The oldest of all, going back to Greek times. Philosophers call it fatalism or determinism. A fatalist believes that everything that happens is predetermined to the end of time; that any attempt to change the predetermined future is fated, is a part of the predetermined future itself. To a fatalist, the future looks exactly like the traditional picture of the past. Both are rigid, inflexible. The introduction of time travel would not alter the picture at all, for any attempt on the part of a time traveler to change the past has already been made, and is a part of the past. Fatalism has been the basis for many a tale of a frantic time traveler caught in a web of circumstance such that every move he makes acts to bring about just the calamity he is trying to avert. The standard plot sketch is reminiscent of Oedipus Rex; when well done it has the same flavor of man heroically battling Fate and losing. Notice how fatalism solves the Grandfather Paradox. You can't kill your grandfather, because you didn't. You'll kill the wrong man if you try it; or your gun won't fire. Fatalism ruins the wish-fulfillment aspect of time travel. Anything that averts the Grandfather Paradox will do that. The Grandfather Paradox is the wish-fulfillment aspect. Make it didn't happen. The way to get the most fun out of time travel is to accept it for what it is. Give up relativity and the conservation laws. Allow changes in the past and present and future, reversals in the order of cause and effect, effects whose cause never happens... Fatalistic time travel also allows these causative loops, but they are always simple, closed 1oops with no missing parts. The appearance of a time machine somewhere always implies its disappearance somewhere-and somewhen else. But with this new, free will kind of time travel… We assume that there

is only one reality, one past and one future; but that it can be changed at will via the time machine. Cause and effect may loop toward the past; and sometimes a loop is pinched off, to vanish from the time stream. The traveler who kills his six-year-old grandfather eliminates the cause of himself, but he and his time machine remain-until someone else changes the past even further back. Between the deterministic and free will modes of time travel lies a kind of compromise position: We assume a kind of inertia, or hysteresis effect, or special conservation law for time travel. The past resists change. Breaks in time tend to heal. Kill Charlemagne and someone will take his place, conquer his empire, mate with his wives, breed sons very like his. Changes will be minor and local. Fritz Leiber used Conservation of Events to good effect in the Change War stories. In TRY AND CHANGE THE PAST, his protagonist went to enormous lengths to prevent a bullet from smashing through a man's head. He was sincere. It was his own head. In the end he succeeded-and watched a bullet-sized meteorite smash into his alter-self's forehead. Probabilities change to protect history. This is the safest form of time travel in that respect. But one does have to remember that the odds have changed. Try to save Jesus with a submachine gun, and the gun will positively jam. But if you did succeed in killing your own six-year-old grandfather, you would stand a good chance of taking his place. Conservation of Events requires someone to take his place; and everyone else is busy filling his own role. Except you, an extraneous figure from another time. Now Conservation of Events acts to protect you in your new role! Besides, you're already carrying the old man's genes. Certain kinds of time travel may be possible; but changing the past is not. I can prove it. GIVEN: That the universe of discourse permits both time travel and the changing of the past. THEN: A time machine will not be invented in that universe. For, if a time machine is invented in that universe, somebody will change the past of that universe. There is just too much future subsequent to the invention of a time machine: too many people with too many good motives for meddling with too many events occurring in too much of the past. If we assume that there is no historical inertia, no Conservation of Events, then each change makes a whole new universe. Every trip into the past means that all the dice have to be thrown over again. Every least change changes all the history books, until by chance and endless change we reach a universe where there is no time machine invented, ever, by any species. Then that universe would not change. Now assume that there is an inertia to history; that the past tends to remain unchanged; that probabilities change to protect the fabric of events. What is the simplest change in history that will protect the past from interference? Right. No time machines! NIVEN'S LAW: IF THE UNIVERSE OF DISCOURSE PERMITS THE POSSIBILITY OF TIME TRAVEL AND OF CHANGING THE PAST, THEN NO TIME MACHINE WILL BE INVENTED IN THAT UNIVERSE. If time travel is so manifestly impossible, why does every good and bad science fiction writer want to write a new, fresh time travel story? It's a form of competition. No writer believes that a field is completely mined out. And no field ever is. There is always something new to say, if you can find it. Time travel can be a vehicle, like a faster-than-light drive. Our best evidence says that nothing can travel faster than light. Yet hard-headed science fiction writers constantly use faster-than-light spacecraft. If a character must reach the Veil Nebula, and if the plot demands that his girl friend be still a girl when he returns, then he must needs travel faster than light. Similarly, it takes time travel to pit a man against, a dinosaur, or to match a modern man against King Arthur's knights. There are things a writer can't say without using time travel. Then, time travel is so delightfully open to tortuous reasoning. You should be convinced of that by now. The brain gets needed exercise plotting a story in a universe where effects happen before their causes; where the hero and his enemy may be working each to prevent the other's birth; where a brick wall may be no more solid than a dream, if one can eliminate the architect from history. If one could travel in time, what wish could not be answered? All the treasures of the past would fall to one man with a submachine gun.

Cleopatra and Helen of Troy might share his bed, if bribed with a trunkful of modern cosmetics. The dead return to life, or cease to have been at all. Bothered by smog? Henry Ford could be stopped in time, in time... No. We face insecurity enough. Read your newspaper, and be glad that at least your past is safe. The End

About this Title