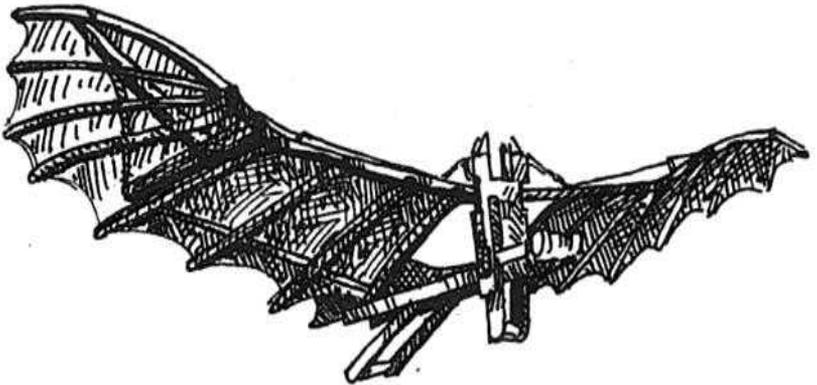


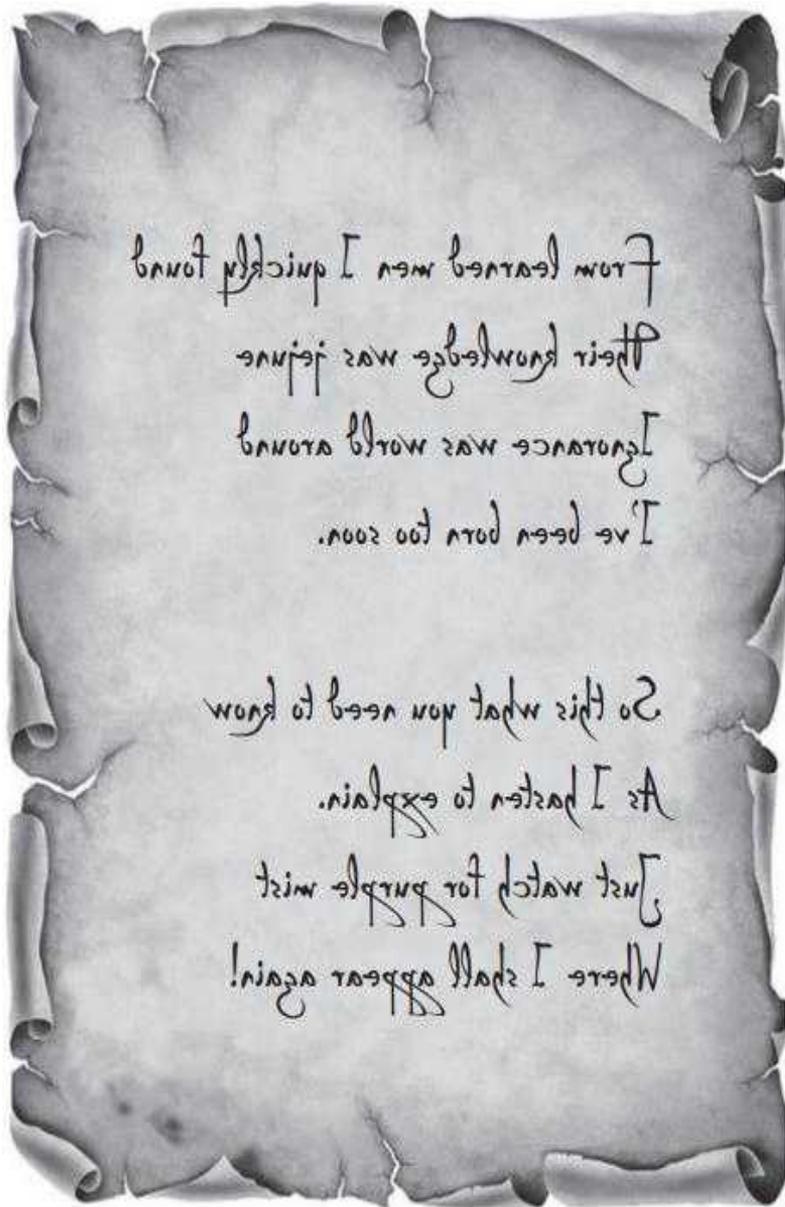
Innovators in Action!

Leonardo da Vinci Gets A Do-Over

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Science, Naturally!®
Washington, DC



Translated from a Leonardo da Vinci codex
... yet to be discovered.

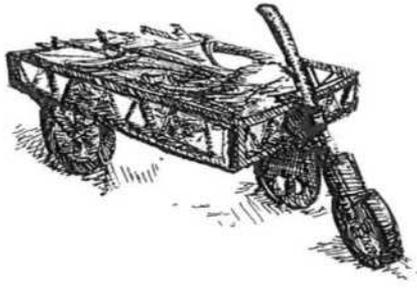
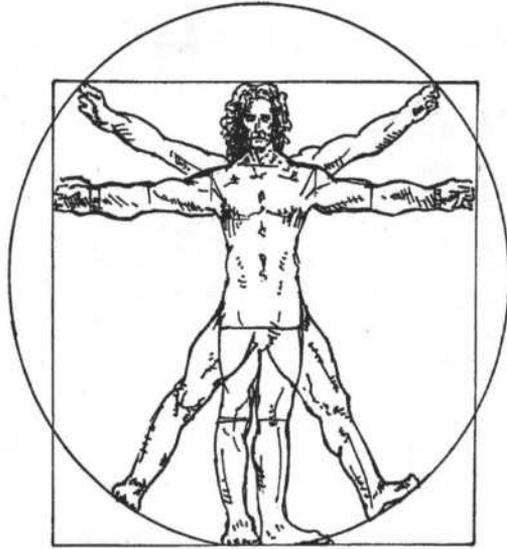


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PROLOGUE

Leonardo da Vinci's last memory was of dying. It was May 2, 1519. The room was sealed from the glorious spring weather by massive, tightly drawn curtains. Only a few candles flickered in the room, allowing for the darkness that suited death. Outside of Clos Lucé, the manor house provided to him by the King of France, Francis I, the sun-splashed spring day was filled with the songs of birds and the distant sounds of people. Leonardo was perched on thickly piled pillows. His entourage, including King Francis I, himself, was gathered beside his bed for what were to be Leonardo da Vinci's final hours.

As he lay in bed, he felt life ebbing from him. For months, he suffered from a paralysis of his right arm and part of the right side of his face. For this ailment, he was treated with salves extracted from herbs and local plants, but, as he had suspected, they didn't work.

The last thing that rang in his ears on that final day was the words a strange gypsy woman uttered when she slipped into his bedroom a few days before. His memory of the ragged gypsy's visit was blurry at best—if it had indeed been an actual occurrence and not just the feverish dreams of a dying man.

He opened his eyes at the sound of footsteps, heavy breathing, and a foul odor to see a woman make her way to the edge of his bed. She was bent with age, shaggily dressed, and cloaked in a tattered shawl. He tried to cry out, but could not emit any audible sounds. He could only watch her, suspicious and curious of her intentions as she stopped at the side of his bed.

The old woman shook her head and muttered inaudibly. Then, raising her eyes and her arms toward the ceiling, she spoke loudly in a Vlach Romani dialect Leonardo recognized but did not understand. The curtains began to sway, but there was no breeze. The gypsy seemed to take the mysterious movement as a response to her query as she nodded and turned back to look down at Leonardo once more.

Then she spoke again, softly this time and as if speaking from the bottom of a well. He did not know the language, but strangely, he understood. As she spoke, he drifted in and out of slumber.

“Leonardo da Vinci, son of the high born notary, Ser Piero da Vinci, and Caterina, a peasant woman, with whom he was not joined by law or the divine, your birth into this life was not as planned,” crooned the gypsy. “You were destined for the future. Your birth was a mistake. To correct this, you will be given a second chance, an opportunity to do what you might have done. This do-over is yours because your potential has yet to be reached. You have more to give. But know this,” she warned, raising a crooked finger, “If you do not wish to die a second and more painful death, you must not waste your genius. You must invent or discover something that benefits all mankind.”

Those were the last words Leonardo remembered, but he had dismissed them as a voice in a dream. But now, those words rang in his ears. The doubt he had felt about her pronouncement vanished.

Leonardo had no clear idea how much time had passed between his death and the present moment. All he knew was that he was now twisting slowly in a vortex of swirling mist. To fly had been his biggest dream. During his life, he had tried to design a flying machine. Now he was flying, without a machine.

Leonardo filled thousands of pages with notes and drawings during his lifetime, recording all of his ideas and thoughts. But here in this vortex, as he considered the gypsy's prediction, he could not recall anything he had done that had been remarkable. He had had many ideas, but never put any of them to use. He designed inventions that he never went on to build. He realized that he had rarely finished a project, except for a handful of paintings for which he had been paid a fee. He worked for over four years on his favorite painting, the *Mona Lisa*, but when he died, he still felt that it was a work-in-progress. He wondered now what had become of his cherished painting.

As he rose steadily upward, he understood that his death took place a very long time ago—though he had no idea how much time had passed. He became aware that he was growing younger and younger. Waving his right arm, he was astonished to find it was no longer paralyzed. He shouted into the dense mist for the joy of the moment, his voice clear and strong. Strength returned to his body. A thrill surged through him as he understood that he was, indeed, alive again.

Slowly, the mist turned from white to red. The red deepened as he turned and examined his hands. They were not the wrinkled and gnarled hands he remembered from his deathbed, but instead the slender, powerful hands of middle years.

The mist slowly changed from red to orange, and the orange lightened to yellow, as though Leonardo were being transported through a prism. He waved his right arm again, but it had no effect on the mist. He continued to slowly twist and rise, lifted by an invisible but gentle force.

From yellow, the mist turned to green. He studied his hands again, bending and straightening his fingers nimbly. He lifted his long beard and saw it had become a thick golden yellow. As the mist darkened from green to blue, he began to hear

sounds. There were voices in the distance and a strange whirring and humming he could not identify. Darkening more, the mist turned blue, then shifted to a deep, rich purple. The mist hissed loudly, the spinning increased, and a powerful wind whipped his tunic, making him shudder.

Then, as if he had just stepped onto a stage, he felt hard ground beneath his feet.

In that instant, the wind, the spinning, and the howling all stopped. The air was suddenly still, and he found himself standing on a rough, gray street among a crowd of people. Their clothing was strange—many of the women and all of the men were wearing trousers, but no cloaks, and the skirts the women wore were much shorter than were customary for women in his lifetime. Some of the younger men and women wore shirts with strange writing on them. The people stood taller, talked faster, and with a different dialect. Their hair was cut shorter. Some walked about with white smoking sticks in their mouths. The place was familiar, but also strange.

He looked around. No one seemed to notice his arrival. They were all chasing papers and hats blown by the brief burst of wind. The envelope of mist and clouds was gone. His eyes adjusted to the beautiful sunlit day. Amid the distracted crowd of people, he realized he was standing in the middle of the central piazza of Florence, a piazza he knew well. He remembered some of the buildings and marveled at others. The giant statue of David still stood. He was back in the Piazza della Signoria in his beloved Florence. He was home.



1. THE MEETING

Dr. Willard Kastleboro was a dark-haired, slightly balding middle school history teacher whose academic passion was the Renaissance. He was average in height—well, maybe slightly less than average—and still trim enough to wear a belt without the need for suspenders. One part of his job that he particularly enjoyed was leading field trips with some of his eighth grade students.

He favored taking students to famous cities in Italy, perhaps because they were steeped in history-rich culture that could bring more meaning to his lessons. Or maybe it was simply because he spoke fluent Italian. Privately, he admitted that he quite enjoyed showing off his advanced language skills in front of his students.

On this particular trip, he was joined by two colleagues. One was Emily Willoughby, a tall and self-possessed math

teacher. The other was Gabrielle Howdershell, a brilliant teacher who was regarded as a walking encyclopedia of science.

Last year, Dr. Kastleboro and a few of his co-workers had taken a group of students to Rome to get a feel for the history of the Roman Empire. The year before, he led a group to Venice to study the 14th century trade wars between Venice and its rival city-state, Genoa. It was now the year 2000, and they were on the cusp of a new and promising century. The group was in Florence to study Leonardo da Vinci in the birthplace of the Renaissance. The teachers planned to offer lessons derived from a study of the 15th and 16th centuries, along with an understanding of the world during the Middle Ages. It was a time when Europeans had begun to search for a better understanding of the world in which they lived.

On an early afternoon, Max, Tad, and Gina accompanied Dr. Kastleboro to visit the famous Piazza della Signoria. The three were finishing their final semester in middle school and were anxiously looking forward to the excitement and challenges of high school. Their close friendship was a mystery to their classmates, since their backgrounds were vastly different. Even so, their new relationship was strong. In fact, it had only been three months since they had first met.



Tad, whose full name was Theodore Jefferson Sullivan, had arrived at Longfellow Middle School in Falls Church, Virginia, just as the new semester began in January. His family's arrival in Northern Virginia was an exciting beginning in his life. The suburban surroundings were in stark contrast to his earlier years in Rivertown.

At 14, he was older than most of his classmates. Growing taller over the past year, he felt awkward at this new height. The ever expanding distance from his eyes to his feet required him to readjust how he walked and ran. His skinny boyish body was transforming into one belonging to a strong and hearty young man.

His family moved to Falls Church when Tad's father was offered a new job. For Tad, the new school was a welcome change. He had not been happy in Rivertown, a small mill town nestled in a valley in the Appalachian Mountains of southwest Virginia. It seemed to Tad that most of his school days at Rivertown Middle School had been devoted to avoiding his predator, Mike Baldwin. The bully tripped Tad in the hallway, stole his homework, snatched his lunch, and called him names like "moron," "lame brain," and—Mike's personal favorite—"Taddy-Waddy."

Tad never told his parents or anyone else how he was treated because that would only reveal his own cowardice, and Rivertown was not a place for sissies or crybabies. Some of his friends told him to stand up and fight, but he was too afraid to try. Luckily, his family moved before things escalated any further. By January, Tad was in a new school and a new community, far away from Mike and Rivertown.

It was cold and blusterous on that first day Tad stepped off of the school bus and followed the stream of students flowing into the crowded halls. This was his chance to reinvent himself. No one at this school knew him yet. Here, he could be confident and cool. All he had to do was act sure of himself and no one would know he felt the opposite. Searching the locker numbers along the hall, he quickly found the one assigned to him.

While he was storing his new books and his jacket, he noticed a tall boy jamming his finger against the chest of a smaller boy. The tall boy had brown hair, angry eyes, pale skin, and a sharp, nasal voice. The smaller boy was dark-skinned, with sparkling brown eyes that shone behind round, black-rimmed glasses. In contrast to the other casually dressed students, he wore a white shirt and a red bow tie. Tad stopped putting away his books and watched.

"You're new here, aren't you?" jeered Neville, the taller boy.

"That's true," answered Max, the shorter boy.

Max's real name was Harlan Maxfield Peabody. From an early age, he was often teased because of his name, so he decided to just go by Max. He wasn't sure why Neville was

hostile, but he figured he'd learn soon enough. He straightened his back, standing as tall as his limited height would allow, but he was still a few inches shorter than Neville.

From the time he was two years old, Max showed a remarkable talent for numbers. His parents were astounded when he began lining his numbered blocks up in numerical sequence. By the age of four he could add, subtract, multiply and divide numbers in his head.

As he grew, his Uncle Bill urged him to practice shooting baskets. "Basketball is the sport of kings," his uncle said. When it became apparent that Max was not going to be tall like his brothers, his uncle switched his campaign to golf. "Great game, golf. No size requirement, but you have to learn young. Sports, boy, sports are where you make your fortune." Then he'd chuckle. "Unless you can sing or dance. But you can't."

His mother, on the other hand, would always pull him aside after a visit with Uncle Bill and say, "Listen, Max, my brother means well, but don't listen to him. Study hard. You can do whatever you put your mind to."

Neville shoved Max against the lockers, sneering. "You know, you're pretty short for your size, kid."

"No," replied Max, fixing his glasses. "I'm just short for my age."

"You some kind of wise guy?" Neville gave Max another shove.

At that moment, Tad took a deep breath to summon some courage, reminding himself that he had no history of cowardice here, and stepped into the confrontation. "Hey, whatcha doing picking on a smaller guy?"

"Butt out," replied Neville, looking at Tad, who was as tall as he was, but heftier, and then back at Max.

Tad took a step forward. No one spoke.

Then Neville sneered, "I should have noticed before. You two look alike. You must be brothers." Leaning close to Max, he added, "Listen, short stuff, I know who you are. They call you Mathematical Max. Every year, the school has a math competition. I won last year, and I plan to win this year. I don't know if you're really a math whiz or all talk, but stay out of the

contest. Just remember that I'm the president of our class, and if I like you, then your life in this school can be very pleasant. On the other hand, if I don't ...” He stopped, paused, looked at Tad, then back at Max. “Just don't enter.”

Max cocked his head, adjusted his glasses again, and spoke. “Thanks for telling me about the contest. I'm sure I'll be entering.”

“Best you don't,” Neville said, eyes flashing.

“This meeting is over,” said Tad, moving slowly toward Neville, who turned and walked toward his next class.

“Just don't, short stuff,” Neville called back before he was out of earshot.

Max and Tad watched as he disappeared into the crowd of students.

“Thanks,” said Max, holding out his arm to Tad for a fist bump. “I'm Max.”

Tad returned the fist bump. “I'm Tad,” he said. “What was that about?”

Max answered, “I have no idea, but if it involves math, then I want to be in it.”

“Who was that guy?”

“Neville Kraxton. Believe it or not, he's the eighth grade class president.”

“Has he been bullying you?”

“This is the first time, but it probably won't be the last,” Max said glumly.

“You can count on me to help out,” said Tad, gathering his books. “See you in the lunch hall, okay? We newcomers need to stick together.”

“Great,” replied Max, knocking his glasses crooked as he put on his backpack.



They met for lunch in the school cafeteria every day after that. Soon, Max and Tad noticed a girl sitting alone. At the table next to her, other girls were laughing and talking; they seemed to be deliberately ignoring her. They looked at each other and, without saying anything, walked over.

She had deep brown eyes and wavy chestnut hair past her shoulders. “Mind if we join you?” asked Tad. “We, uh, need your expertise on something.”

The girl’s eyes lit up. She smiled, revealing a mouth full of metal.

“I’m Tad. This is my friend, Max.”

“Hi.” Max smiled as they sat down.

“Max?” She raised her eyebrows in question. “Aren’t you the guy they call Mathematical Max?”

“That’s me,” replied Max.

“I’m very happy to meet you, both of you.” She didn’t want them to feel sorry for her, but she had been watching them during lunch and had secretly hoped that one of them would talk to her. They seemed friendly. “I know you guys made up an excuse to join me, but it’s so great that you did.” The girl was known for never being anything less than blunt and direct.

“Well, we—” Tad began.

“And I want you to know I’m honestly grateful,” she interrupted. “I’m new this semester, and the other girls haven’t welcomed me. They think I’m too fat and my big braces make me look ugly. I’ve noticed you two at lunchtime and saw that you weren’t hanging with the other guys. I haven’t made any friends here yet. I’ve been living with my family in Italy for three years, so everything here is new, and to tell you the truth, I’ve been really lonely.”

“Wow,” said Max. “You sure are a fast talker.”

“And a straight talker,” said Tad. “What’s your name?”

“Oh, sorry,” she said. “I’m Gina.”

Within a short time, Gina became the third member of this unlikely group. Her mother was Italian and had met and married Gina’s father during his first tour of duty at the naval base in Naples, her hometown. As the child of an active duty officer in the United States Navy, Gina had lived on naval bases throughout the world.

Dr. Kastleboro and the teachers welcomed her to join them on the Florence trip in the spring, pleased that she spoke fluent Italian. Tad and Max were glad she was going because she was

always pleasant and outspoken and made them feel comfortable with whatever subject they discussed.

Later that week, Max, Tad, and Gina gathered at lunch to prepare for the upcoming math competition.

Every year, Ms. Willoughby hosted the school's *Math Madness* competition the week before spring break. The contest this year was to come up with an exciting way to explain the size of a billion and present it in an educational outreach project to a fourth grade class at a nearby elementary school. The prize for the winner, or winning group, was exemption from the mid-semester examination.

She explained to the class that the previous year's winning group, led by Neville Kraxton, came up with a mathematical way to calculate the height of the school flag pole. They did this by using the ratio of the length of the shadow of a yardstick to the length of the shadow of the flag pole. Neville had held up a yardstick and measured the length of its shadow, which turned out to be $1\frac{1}{2}$ feet, or half the length of the yardstick. Since the shadow of the flagpole was 10 feet, he calculated that the pole must be 20 feet tall.

"Max, what do you think?" Gina asked.

"I think it's easy to demonstrate how big a billion is," he replied.

"A billion what?" Tad asked

"Doesn't matter," Max shrugged.

"So, how do we do it?" pressed Gina.

"I've been thinking about it, and I think it'd be simplest if we calculated the volume of a billion marbles."

"Marbles?" Gina asked, "Why marbles?"

"Because I have a great collection of marbles," Max added, "Tomorrow, I'll have the answer."

The next day, Max had the entire plan outlined. With Gina and Tad's help, he filled a quart jar with marbles. Three hundred and ten marbles filled the jar. Simple mathematical conversions determined that one cubic foot would hold 29.92 quarts, which meant that if you multiplied 310 marbles in one quart by 29.92 quarts, you would know that there would be

9,275 marbles in each cubic foot. Thus, one billion marbles divided by 9,275 marbles required a vessel of 107,816 cubic feet. This meant that a billion marbles would completely fill a high school gymnasium.

Neville's group came up with the number of years it would take to count to a billion if you counted one number per second. As he explained to Ms. Willoughby, "There are 86,400 seconds in a day. It would take a group counting nonstop for 24 hours a day a little more than 11 days to reach a million (1,000,000 divided by 86,400 = 11.57 days), and since a billion is a thousand millions, then it would take almost 32 years to count to a billion (11.57 x 1,000 = 11,574 days divided by 365 = 31.71 years)."

Ms. Willoughby thought the concepts were imaginative, and Neville's group and Max's group nearly tied for first place. In the end, Max and his friends were awarded the first prize and Neville's group came in second. Ms. Willoughby said that Max's group won because a gymnasium full of marbles was easier to visualize than a group of people counting. Neville said nothing. He just glared at Max menacingly.

And now, not only were Max, Tad, and Gina in Florence, but so was Neville, along with a number of other students from their school.



The class had been in Florence for two days when Dr. Kastleboro and the three friends decided to take a refreshment break. Dr. Kastleboro suggested the Rivoire, an outdoor café at the far corner of the Piazza della Signoria. They sat outside at the corner of the potted-plant-lined enclosure. Dr. Kastleboro sipped a cappuccino while the three students each enjoyed a gelato.

Beyond the café, crowds filled the piazza. The bright sun warmed the early April afternoon. On the other side of the piazza, in the shadow of the Uffizi, the major art gallery of Florence, a young man played American love songs on his electric guitar. Coins and bills filled his guitar case, and some

tourists bought CDs of his music. The music was soothing and Dr. Kastleboro felt relaxed. He enjoyed the warm afternoon sun, wondering what life must have been like in this same piazza in times long past.

From their vantage point, Tad, Max, and Gina could see other touring students trying to ignore their chaperones. Amidst a plethora of languages, they watched huddled groups of older men and women struggling to decipher their guide books. On one side of the piazza, along the wall of the Uffizi, there was an open gallery of statues glorifying the centuries that comprised the Renaissance. Around them, other cafés overflowed with visitors resting and glancing at their menus.

The three middle school comrades happily and energetically chatted amongst themselves, mostly about the 17-foot copy of the famous marble statue of David, sculpted by Michelangelo, standing boldly naked above the crowd. Tad and Max were embarrassed just looking at it. Gina sensed their uneasiness and tried to appear casual, but she couldn't entirely suppress her giggles.

"Certainly a very important statue," she said, rubbing her chin in an intellectual pose, but then she broke into giggles and added, "Come on, guys, don't be embarrassed. Just appreciate the artistry."

Dr. Kastleboro explained to them that they were in the heart of a piazza that had been the center of Florentine government and politics in the Middle Ages. The city had changed very little from its Renaissance appearance due to careful preservation.

"During their lifetimes, both Leonardo da Vinci and Michelangelo Buonarroti were the artistic heroes of Florence," he said. "Leonardo was older, but after being charged in a scandal, he fled to Milan. In his absence, Michelangelo replaced him as the artist darling of Florence."

None of the students responded, far too distracted by the statue of the giant, naked man. They didn't even ask about the nature of the scandal.

As they watched, a dark cloud, out of place in the otherwise sunny sky, rolled in from the hills beyond the Arno River. The