Farther and Alien

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Thank You

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Pronunciation

'D' and 'G' are hard, as in 'doll' and 'gulf'. 'J' is soft, without a 'D' sound. It is a French 'J', as in 'Jean'. Hence, the combination 'DJ' in 'Djem' causes the name to sound like 'Gem' in English.

'AE' is a long 'A', as in 'name'. In English, the name 'Djaeds' is spelled 'Djades', where a vowel is made long by following it by a consonant and a silent 'e'.

'OE' is a long 'O', as in 'lope'.

'AI' sounds like the 'ie' in 'pie', and 'AU' like the 'ow' in 'cow.' Thus, the word for dozen, 'pau', is pronounced 'pow.'

The word for 'firstly,' 'pamai', is pronounced 'pammie' in English and the name 'Pamaitcas', or 'First City' (a very unoriginal choice) is pronounced 'pammie-tchas.'

Single vowels are pronounced: 'A' as the 'a' in 'father' or 'lava'; 'E' as the 'e' in 'met' or 'get'; 'I' as the 'i' in 'machine' or the English 'pizza'; 'O' as the 'o' in 'lop' or 'top'; 'U' as the 'oo' in 'boot' or 'loop'.

Being at the end of a name, the 'S' in 'Djaeds' is softened to a 'Z' sound, but that does not matter. It can be pronounced with a hard 'S' hissing sound. (The same may happen with an 'S' near the end of the word and preceding a vowel.)

Chapter 1

The alien took more than six dozen years to reach the star.

The new stellar system looked good.

The alien did not navigate himself. His computer made the observations and calculations — even though Gell had been uploaded into the machine, he still thought of it as 'his computer' and 'his space ship'.

In slowing from his interstellar transit, the alien approached closely to the central star. As planned, the multiple sheets of thin metal, the vacuum, and the remains of cold, solid hydrogen all shielded him and his passengers from the heat. Although he was part of a short, thick rod buried in hydrogen, the overall space ship was spherical. The sheets of metal not only enclosed the hydrogen that provided the sphere of plasma with which the space ship had been pushed and protected, they enclosed the helium-three that fed the miniature fusion reactors that had powered the plasma generators and computers during the trip. Almost all the stores were gone. Like a humans' interstellar space ship, assemblers by the home star had built solar collectors and particle accelerators to push the huge artificial magnetospheric plasma that surrounded the vehicle. After its near encounter with the new star, the space ship moved outwards, much more slowly, towards the Jovian planet.

From home, telescopes had detected small objects in orbit from which the assemblers could build large machines. Even though the space ship was too small to carry big sensors, let alone high resolution ones, it carried sensors that were large enough and found the planetoids. Moreover, it extracted spectra from the Jovian planet that indicated it had the large magnetic field needed for movement in its vast gravity.

The new star was brighter but the Jovian planet orbited more than a third farther out than Gell's own original. Over all, it received a bit less light. In among the planet's high rising clouds, Gell saw lower down. His instruments determined, as expected from very distant observations, that as altitude went down, its atmosphere gained sufficient pressure and temperature to host him and his kind. And, also as expected, the planet was dead! No only did it fail to possess any of the large, living islands like those that floated in his own atmosphere, the atmosphere lacked life-suggesting out-of-balance characteristics. He could seed it happily and eventually be downloaded to an organic body in it.

Neither Gell nor his computer ever noticed the small, non-natural movements near a rocky, low gravity, low magnetic field planet much closer to the central star.

Chapter 2

Djem Dorodden took five dozen years to reach the star.

As expected, Djem woke with a blink. That was fine. But something was wrong! He did not wake in an organic, biological human body; he woke in a humanoid robot body. He wondered how many years had passed. Had he reached Ulterius?

A human-level, artificial intelligence welcomed him. The AI wore a humanoid robot body that looked somewhat like a general purpose human body. The robot's skull was covered with dark threads to indicate dark hair, his eyes were dark. Like almost all humans, the robot was tall and well built.

The AI said, "You are near Ulterius. You have traveled from Melior. It has taken five dozen years. Everyone else is fine; none of them has been injured by a stray cosmic ray or whatnot." He paused for a moment. Like the alien, Djem had traveled interstellar in a small cylinder a little more than a twelfth of a meter long, surrounded by solid hydrogen and liquid helium-three in a Dewar with multiple sheets. His new body was as big as the whole space ship. That is why he was reborn.

While waiting for the AI to speak again, Djem had time to look around. The room was similar to the one in which he woke the first time near Melior after an even longer interstellar voyage. The bed itself was in the alcove of an L-shaped room. It was next to a wall with wood paneling. Djem could see a desk and straight-backed chairs in the bigger space as well as an exit door with a full length mirror on it. The plain floor looked wooden, like the walls, but darker. As he promptly discovered from one or other data source, the room was built according to the same design as the one by Melior, except it had no display screen above his head and none on the table. After all, he was in a robot body; he was not organic. He knew how to connect internally. Otherwise, it was similar.

The AI continued, "I am waking you and the others early. There is an emergency. That is why you are in an inorganic rather than organic body. I have not yet had time to grow your organic body." He stopped again. To Djem, the wait was long.

Djem stood. Although he was not wearing any clothing, he felt dressed. In the mirror, he saw his own dark brown eyes and on his head, somewhat like a rug, dark brown hair. Like his organic, biological self, this body was stocky and moderately tall.

Finally, the AI explained the emergency. "Sensors detected an alien space ship entering the planetary system. We would never have seen it except that von Neumann assemblers built hordes of sensors around the

three Melian stars. That included Ulterius although it was unsettled at the time."

Because of the fear of an Earthly attack, an attack that never came, assemblers had constructed numerous detectors. They had a function after all.

Djem suddenly was very glad he had decided to come.

Djem Asks

First, however, Djem asked how Melior's telescopes had managed to miss any technological entities the aliens had produced? "Surely," he asked, "the alien space ship has not come from more than a gross of light years away?"

"No," the AI explained. "it headed towards the system's Jovian planet. It is not coming near any terrestrial planet. Indeed, the aliens it carries do not appear to have noticed us."

The AI explained further, "Looking back on the aliens' course, Xi Bootis is the only nearby star. I should talk in the plural; Xi Bootis is a double. Its second component takes over a gross of terrestrial years to orbit the first and is much dimmer. The double star is a dozen plus seven light years away. I fear the aliens first went to other systems closer to Xi Bootis, but I don't know."

The computer went on, "I presume there is a Jovian near Xi Bootis, perhaps by the brighter or A component."

The aliens continued to ignore the humans.

Chapter 3

The AI woke the other humans who had chosen that their minds be reborn in inorganic substrates. “It is distressing for people who chose to be reborn in an organic substrate to be reborn into an inorganic one,” he told Djem. “We have enough people anyhow.” Most people insisted on staying with brains as organic as the rest of themselves.

They came into a central, larger, rectangular room and sat around a small, circular table. With his robot eyes, Djem could see that the floor curved a little in one direction, but not the other. Organic eyes would not have been able to see. The wooden planks that made up the floor were no more than a third of a meter wide with their lengths in the flat direction. As expected and as he determined from his internal communications, they were on a large, rotating space station, a big wheel. It was built to the same specifications as the one by Melior. The wooden planks had been assembled atom by atom from a comet with the right elements. Metal served to contain pressure. The wood was for humans.

As Djem saw, none of their robot bodies could be confused with the bodies of organically grown humans. Early on Melior, he learned that as a matter of policy, the Melians made sure that small children could easily distinguish all robots, especially talking robots, from all organic humans. This was to confirm the children’s notion that talking did not indicate sentience. Since few children on Melior met sentient entities who did not wear organic, biological human bodies, the visible forms of the bodies tracked the invisible forms of sentience. Instead, children almost always met sentient entities such as AIs in organic bodies that looked human.

This was different. The sentients wore inorganic bodies, robot bodies. Had there been any children, they would have been confused. Each robot enjoyed a flexible, outer metallic cover. It looked golden with black dots spaced like human hairs. Nonetheless, when he met them, Djem found he could recognize the others from his memories of their organic human look. They looked like robots, but were not hugely different from humans.

In her organic body, Leestel possessed dark eyes and light brown hair. To Djem, the robot that carried Leestel’s mind had hair that looked like a light brown carpet on the top of her head. It must have been intended to symbolize her hair. As with her organic body, the robot itself was slightly thinner and a little shorter than Djem’s.

The robot for Djaeds Summervil enjoyed, if that was the right phrase, the craggy good looks of an old-style politician — on Melior, he had been a second-rate political leader.

Unlike the hitherto organic humans, both Telren Dowwen and Tuppak Nassik came awake in babboid-looking robots. Neither looked human. They looked babbo, somewhat like centaurs. Even so, for the moment anyhow, they clearly existed in bodies that were manufactured out of metal, not grown as organics. The two had been first born into human shape like the others. Telren had elected to be reborn as a babbo on Tegmar, the second living planet in the Melian system. He persuaded Tuppak and both had decided to be reborn in organic babbo bodies in the Ulterius system albeit with their minds in inorganic substrates.

The original organic babbos on Tegmar had four legs and two arms. They possessed two forward looking eyes that provided binocular vision. Their front appendages were furry like the rest of their bodies, a deep brown. Unlike human arms, they were not (relatively speaking) hairless. Even though their front appendages served as hands, much of the time they walked on them. Natural babbos could not speak, but on Ulterius humans in their shape could, whether metal or organic. (On Ulterius, there were no natural babbos at all, only babbos with human minds. Tuppak Nassik had modified the organic design.) Babbos had more teeth than humans.

A babboid robot possessed a strip of brown tendrils down the center of its back – Djem thought of the strip as a narrow rug. Evidently, it was supposed to convey the memory that babbos' organic, biological bodies were covered all in brown fur. Like the humanoid robots, the rest of the babboid robots was covered in a golden, flexible metallic sheath covered with black dots. Just as the humanoid robots would not be confused with organically grown humans, the babboid robots could not be confused with organically grown babbos.

Djem spoke to the computer. "Because of the speed-of-light delay," he said, "you will need to duplicate before going out to the alien." He had never forgot that that delay meant he needed a smart robot when he first left his embassy on Melior and went to the next planet, Tegmar. That robot had dived onto a bomb tossed at Djem. "One of you will have to stay by this planet and the second make the visit."

"That is true," said the AI. "I am named Adkel Ivden. Let's name my duplicate 'Aglar Ivden.'" All artificial intelligences had 'A.I.' as the initials for their names — somehow, that habit had started a very long time before and continued.

The AI did not leave Djem with the time to consider the implications of duplication. Instead, he said, "Our committee members, those of us awake, encompass a good variety of entities: you Djem, a former Earth person; Leestel Kemmel, a civil servant; Djaeds Summervil, a politician whose previous policies have been different; Telren Dowwen, an adventurer who went to Tegmar and settled in a babbo body; and Tuppak Nassik, an ecological engineer."

Djem thought for a moment then asked, “Aren’t Telren and Tuppak both in babbo bodies?” “That is not much of a problem,” said the computer. “They were both reborn as inorganic substrates. Robot bodies are easy to construct. And both Telren and Tuppak learned basics in human bodies; that is what they grew up with. Their language, their embodied metaphors, comes from bodies with two arms and two legs.”

Leestel had never been reborn before. She experimented with her new internal radio; except that the others were indulgent, she would have bothered them by contacting them too often. Then she found that her internal memory contained new items and she could readily gather information from an external memory through her radio. Everything new felt as if she learned without effort.

Djaeds had been reborn before into completely organic substrates. He was glad that this time he was inorganic. He no longer had to reconnect his nerves. Instead, he came awake instantly. He enjoyed the ease. Even though he trusted that the computer had installed extra processors, but not so many that time slowed, he could not tell whether he thought faster than before. He did not feel different.

Chapter 4

As the alien expected before he moved out from the central star, planetoids orbited closer in than the Jovian. Gell had no trouble matching the orbit of one very small rock. There, his assemblers made more of themselves as well as more vehicles and mechanical bodies.

The construction succeeded. His small assemblers made more and bigger ones; altogether, they constructed computers, sensors, manipulators, the solar panels that went to the new interplanetary vehicles, and the vehicles themselves. The rock vanished. Gell made the equivalent of a sigh — he discovered that he had worried lest he be unable to deploy the assemblers successfully, but he had suppressed the feeling.

Gell moved sleeping pilots into the new vehicles and embedded them into larger minds. Each possessed solar power, individual senses, and manipulators, the equivalents of hands.

Then Gell woke them. From the pilots' point of view, each had fallen asleep in orbit around Xi Bootis and came alert here. He noticed that all were relieved to find themselves alive. None had said so, but none were confident this interstellar migration would succeed. It was, after all, the first.

The pilots' vehicles created artificial magnetospheric plasmas to propel them with the help of the interplanetary wind.

Like Gell's, each pilot's name began with a consonant and ended with an L sound. Each included a single vowel sound in between. All originally possessed much longer names, but these interstellar pilots all gained short names — well, only Gell was awake between stars, albeit much slowed down; he was the only pilot who was truly interstellar. Nonetheless, all the first half double-dozen were given short names. Short names were an honor. They also helped bind critical people more closely to home.

Traveling in the new vehicles, the pilots took their new assemblers to larger planetoids. That movement also served as a test. Everything worked. On the larger planetoids, they begin constructing the parts of a transmitter to signal Xi Bootis.

Rill was his second in command. The pilot was very skilled, but had too much self control for Gell's taste. He made a superb second. Another pilot was Moel. As a pilot, she was merely competent but she was an expert with bioforming with living assemblers. She would manage that part of the project. Voel and Kael were other spacemen. They were highly competent as pilots and inorganic assembler managers, but they were not as good organic biologists as Moel.

Gell knew that starting in a very short time, which is to say on Xi Bootis starting in about three of his original planet's years from Gell's present time, a measure of how long information took to crawl from

stellar system to stellar system, those at home would listen for one-sixth of an orbital period. Until they heard, they would not know whether his trip was a success. If they heard nothing, they would presume it a failure.

Chapter 5

The humans had an easy time deciding to contact the alien. They all wanted to learn more. That included the artificial intelligence, the AI, who thought of himself as 'human but improved'.

The AI, Adkel Ivden, duplicated himself. The duplicate, Aglar Ivden, traveled with the other humans from Ulterius orbit.

They traveled in an interplanetary space ship that looked just like those in the Melior system: its body included several stories for passengers, a large solar collector, and four small cylinders arranged around the larger passenger cylinder. The small cylinders generated a huge magnetospheric plasma against which the solar particles of the interplanetary wind pushed. Because the space ship was always in an orbit of some sort, it could readily use the reaction to speed up or slow down. The thrust was not necessarily radial. By slowing its orbital speed, which it did by thrusting against its course, the space ship could move itself closer towards the central star and speed up, exactly as in all the Newtonian texts. In this instance, it did the reverse and moved itself outwards. By pushing forward, the thrusters added energy to the orbit and the space ship in it. The space ship slowed.

Although humans in robotic form could comfortably handle much higher accelerations than humans in organic bodies, high acceleration would not save much time. Only very high acceleration would be quicker. That was, as yet, impossible. Very high acceleration meant sending people by star wisp as dead data packets. But until an assembler had been brought out to the destination and built particle beam projectors to stop it, only the next star could slow a wisp. Unlike an interplanetary vessel, a star wisp could not halt on its own by the alien ship.

So the trip from Ulterius took just under three weeks — counting days in Melian terms. Those days were about the same length as Earth days or Ulterius days.

The alien also traveled outbound. Because Adkel acted so quickly, and because the speeds were comparable, the humans traveled only about two weeks behind the alien. They intercepted him — and his newly woken colleagues — in the outer planetoid belt. The alien ship had not yet gone into orbit around Nebber, the Jovian planet.

First Decision

When telescopes around Ulterius saw that the aliens were building antennas to signal home, Adkel, the AI who stayed by the human planet, presumed that assemblers built them. He also presumed, although he could not see, that the aliens were building transmitters to power the antenna. Adkel informed those on the human space ship. They were

surprised. For whatever reason, even though its existence was rather obvious, neither of the AIs nor any of the other humans expected the alien to possess assemblers.

None of the humans, neither the AIs nor the rest, cared what happened on the system's Jovian. They did not plan to use it. The humans could descend to it, but they could not figure out how to leave it except by radio. They did not know how to push anything material into orbit. From their point of view, an alien on it would be interesting. Besides, this alien or his predecessors had obviously left the original planet, so he knew how to leave.

But to use non-Jovian resources in space: that was a different matter, at least for some. Leestel did not see a problem at all; as far as she was concerned, there was plenty for all.

At first the images provided only faint evidence. Construction had just begun. If the aliens used the same technology as the humans, they would finish the antennas. Later the evidence became more suggestive as the aliens did more work. Once the antennas were built and pointing towards Xi Bootis, evidence became certain. They presented the humans with their first decision.

There was no evidence whether the aliens were good or evil, destructive, or trustworthy. Each had to decide and argue based on his own imagining.

Djaeds Summervil was against permitting the aliens to signal. He argued that their action was dangerous. He wanted to protect humans. As he said, "I know now that the Earth was always safe" — on Melior, he had argued that Earth was dangerous — "but the possibility was there. It is the same with these aliens. Their communicating may be safe, but we don't know."

Tuppak Nassik was for the aliens. He argued generously that "others should be encouraged to do what they wish." He wanted to provide for them. Unfortunately, his moral argument failed to touch the issue. It had been cast as a 'humans win' or 'aliens win', as a zero-sum issue, not as a 'we can all win', a positive-sum issue. In zero-sum thinking, to encourage another species to win meant to encourage humans to lose, something that neither regular humans nor their constructs were willing to do.

Fortunately, Leestel was able to settle the matter. At first everyone else thought she saw only positive results. That was not true.

She pointed out that the aliens would impact humans and Earth people, willy-nilly, and then said, "It is better for us that they enjoy good rather than bad first memories. In the short run, we can prevent communications home. It will not be long before we are unable to. But for now, we can. However, eventually we will have to permit them to communicate. For one, they could have assemblers construct a space

ship that radioed back continuously. It would be bigger than the present space ship; its ancillary equipment would require more material and more construction time than now, but they could build it. As a practical matter, we gain by permitting aliens from the beginning. We need to prepare for the future."

Djem noted another, more horrifying solution: kill them all now. "We still have the power. But," he said, "that only puts off the aliens' discovery of us for a few gross of years at most. At some time, even if we kill this group" — somehow, he had shifted from thinking of one alien on one space ship to numerous aliens — "the aliens at home will discover what happened. So Leestel is right. We should permit communications now and encourage good relations."

Djaeds agreed with that reasoning. Consequently, at the only time when the humans had superior force in the Ulterian system, they permitted the aliens to carry on.

Chapter 6

The first contact was traditional and anti-climatic: the human interplanetary craft stopped relative to and in front of the much smaller interstellar craft. Its appearance surprised Gell, but there was no way he could communicate that.

The human space ship signaled by blinking a prime number sequence in visible and infrared light and in radio at a frequency indicated by the size of the antennas for the aliens' transmission home. Three consisted of three blinks, five consisted of five blinks, and so on.

Since the space ships were vacuum and nothing material passed between them, four out of the five traditional human senses had to fail: touch, taste, smell, and sound. Only sight passed between (and sight's extension into radio at lower electromagnetic frequencies).

The alien also signalled by blinking in visible, infrared, and radio. It added a few numbers. Then it transmitted another sequence, with even more numbers, on a radio frequency near to, but different from that used for signalling home. It doubled and doubled again the speed of its transmission, and kept doubling.

Aglar Ivden, the human AI who had come away from Ulterius, figured the alien preferred this new frequency. Moreover, the increase in speed indicated he could handle high speed communications on it. The AI promptly transmitted back yet more numbers at the maximum rate for the frequency. The alien responded at the same frequency and speed.

That way the two entities agreed on an electromagnetic frequency and speed.

Then, outside the human space ship, non-humanoid robots controlled by the human AI displayed a two by three meter image on a gold plate. The image was made up of visible dots in a nearly golden ratio. The longer side was horizontal — in base two, it possessed 10110011001 dots, which carried enough detail for the humans — and the shorter was vertical.

The image came from a single eye or camera and showed the aliens' space ship, but was drawn with lines for edges. Dashed lines indicated parts in shadow. The image tested for several conventions all at once: whether aliens perceived more or less than humans, whether they understood a view from a single eye, whether they perceived edges as more important than their contents, and whether they accepted the known but shadowed. Were they willing for the directly invisible to be marked? An obviously mechanical arm moved left to right to show one line, then moved downwards for the next.

If the alien responded similarly, there was very strongly suggestive evidence that the aliens both recognized and understood the conventions. Further communications would be much faster. If the alien did

not respond, either it or they did not recognize the conventions or did not understand them.

If he failed, the human AI would try something else. It seemed evident to him that both sides expected confusion, so both the aliens and the humans would tolerate failure.

At the same time the mechanical arm moved left to right, the radio slowly transmitted a corresponding signal, a tone twice the amplitude of the background to indicate an empty space and a tone seven times the amplitude for a full space.

The boundaries of the image were marked, so the first line consisted of nine-gross eleven-dozen five high amplitude radio signals. The next line only had marks at its beginning and end; the rest was 'empty space,' indicated by low amplitude radio signals.

When he first dealt with the alien, Djem translated the base twelve number, nine-gross eleven-dozen five, into base ten. He added together five, eleven dozens, and nine one-hundred-forty-fours. The base ten number resulting was one thousand four hundred thirty-three. He had not realized until that happened that for him base ten was deeply embedded. Perhaps, he thought, that was because he had ten fingers.

Then Djem looked at his left hand. His palm faced him and he had bent his fingers so he saw four finger tips and eight knuckles, twelve in all. He shifted back to counting in base twelve. It never occurred to him to question his looking at his hand, even though he was a grown man. A computer had modified his data before rebirthing him.

Shortly after Aglar had displayed the image, the alien showed he understood by transmitting another image by radio at full speed. The first was simple: a cross in a larger rectangle. The rectangle had the same prime number ratio, indeed, the same numbers, as the humans'. Then the alien sent a line drawing of the humans' space ship.

The human AI recognized the line drawing immediately. The image indicated that the alien understood humans and their conventions and was willing to employ them, too. With dashes, the alien image showed those parts of the humans' space ship that were in shadow. Either it shown in star light or in radar. In addition, the aliens' image showed the farther part of the humans' space ship measurably smaller, as it was farther from the alien. This was a normal consequence of an image from a single, small camera eye. There was not enough information to tell the humans whether the practice started as a convention before the development of cameras.

After the humans received the signal, they felt comfortable transmitting images of what both could know or see. They sent a picture of the aliens' antenna array for transmitting back home and then another of the Jovian planet with its waves and spots as seen from the two space ships.

The humans displayed the two space ship in proper relative size albeit closer to each other than in reality. The humans' space ship was a dozen times longer than the aliens' interstellar craft. Then the humans' AI added a meter length marking to just a picture of the humans' space ship. It was an I-shape.

The alien caught on quickly and promptly sent images of his radio antennas with a meter marker. Aglar Ivden, the human AI, would have sighed with relief had he been able to; the robot in which the AI was embedded did. The sigh was strictly for non-verbal communications. In case anyone missed it, he told the other humans he was relieved.

Next, the alien showed another similar marking beside the meter and changed pictures. It looked the same except it was a bit longer. Then the humans saw that the longer marker was closer to the aliens' space ship and the shorter marker closer to the human' space ship. This time the two space ships were an accurate distance apart. They concluded that the shorter marker was the measure used by humans and the longer was the measure used by aliens.

With dots on an image, one dot for one, two dots for two, and so on, and with longer symbols beside them made up of many dots, the humans were able to show their base twelve numerical system.

The alien promptly replied. He made up an image with three dozen rather than two dozen groups. First, he showed sets of dots, one, two, three, and so on. Second, below the dots, he showed the humans' base twelve numbers, one for each set of dots. Below the humans' numbers, he showed strange symbols which the humans decided were his numbers. Unmarked space separated each group from another.

The aliens' numerical system looked designed around a base twice as large as the humans. The symbols looked to be variations on six fundamental glyphs, each symbol possessing one, two, three, or four vertical lines.

The aliens' number two, shown equivalently both with two dots and with the Melian symbol for two, consisted of a horizontal line with an upward-facing twirl on the left and two short vertical lines to the twirl's right, both on the top side of the line. The number five consisted of a horizontal line with a very short downward line to its left, no twirl, and a single short vertical line to its right, below the horizontal line. Eleven consisted of a horizontal line with a downward-facing twirl at its left end and three short vertical lines to the twirl's right on the bottom side of the line.

In the alien script, one dozen three looked the same as ten, except the twirl was on the right and the three short lines on the left. One-dozen plus five was the mirror image of eight, and one-dozen plus eleven was the mirror image of two.

Leestel said, “I would have expected the symbols to move in sequence from lowest to highest.” “No,” said Tuppak, “a dozen plus one mirrors a dozen, a dozen plus two mirrors eleven; the numbers four up from twelve mirror those four down from twelve. A dozen plus three, a dozen plus four, mirror ten and nine. The numbers two and three mirror the numbers for two dozen less one and two dozen less two. They all mirror each other in a way we don’t expect.”

Then the alien added to the image.

“Look at the way the alien arranged the symbols,” said Tuppak. “The image is the same as before, expect that before the one we see a sequence of our and his numbers with nothing, no dot. That sequence has a zero like the symbol we have beside our number for a dozen and another symbol in what would be, but is not the third row. He is showing us the alien symbol for zero.

“A similar symbol is in his top place for two dozen. The symbol for two dozen and one has a one in that place. The alien must be using a place system just like us, except he has twice our base, a double-dozen for his base. His equivalent of our gross is four gross.

“Moreover, the alien has the zero and the one on the top, so my judgement is that for him, the smallest value is on top, the biggest on the bottom. For us humans, the smallest value is on the right and the largest on the left.”

“That is the opposite of what we would do if we were to write the numbers vertically,” said Leestel. “Yes,” said Tuppak. “The numbers are alien.”

The symbol for zero was a twirl or circle that stretched below a horizontal line.

Aglar promptly extended the image beyond three dozen to show yet more dots and their corresponding base twelve and base double-dozen symbols. The humans felt certain they understood this part of the aliens’ number system and sent yet more numbers.

Then he showed a meter measure beside the aliens’ space ship with a one for the first meter followed by a dot and three more numbers for the fractional part. Including its multiple sheets of thin metal, the aliens’ space ship was less than two meters long. It was much shorter than the humans’ interplanetary space ship.

The alien transmitted the same picture along with the same base twelve number, a one plus a fraction. In addition, he added his own base double-dozen number, a one plus a fraction. Instead of a point he employed a vertical line with no circle beside it. The symbol did not have a horizontal line above or below it either.

Then he transmitted a picture of the human space ship with a meter measure beside it, and provided the correct length both in base twelve and in his double-dozen base. It was definite: the aliens used a plain ver-

tical line to separate integers from fractions that were double-twelfths. In the same place, humans used a dot to separate integers from fractions that were twelfths. The alien numbers extended vertically; human, horizontally.

In another image, the humans showed the two space ships, then showed them smaller and smaller, and finally were able to connect the two with a line and mark the line with a number that indicated the distance between the two in meters.

The alien responded by showing the distance in his measuring unit. Then he made a picture of his space ship and of his radio antennas and made them smaller and smaller. Eventually each became a dot. Then, he drew a line between the two dots and labeled the line with the proper distance both in meters, as indicated by his use of human symbols, and in his unit as indicated by his use of his own symbols.

The humans and the aliens exchanged images showing the distances to the system's Jovian planet, to the other major planets, and to the central star. They connected parts of the images with lines, which meant everyone had to understand lines as well as the conventions for shrinking.

It all worked out easily. Djem asked himself whether every intelligent species that used images would consider edges, marked by sharp contrast, as more important than anything else. 'Perhaps they would,' he thought. 'Would they also interpolate what they could not see directly?' he asked himself. 'Maybe.' He did not have enough evidence to speak of aliens in general, but was thankful that these aliens were not too strange.

Then the humans transmitted a picture of the aliens' interstellar space ship with the two measuring sticks. Gell understood that easily, but did not understand why the humans did this. There was no way to express his confusion, so he simply waited.

Next, the humans transmitted images of the Jovian, the other major planets of the Ulterius system, and the antenna array pointing towards Xi Bootis. Again, Gell understood the images, but not why they were transmitted.

Then the humans transmitted an image of the bright stars that came as part of a view of Xi Bootis. Xi Bootis was at the center.

It took a moment for the aliens to understand the image; they saw many more stars. The limited human view looked very strange.

Another pilot besides Gell finally thought to show himself an image of the few brightest stars, an image of the brightest plus the next brightest, and so on. Rill's third image duplicated the humans.

Rill told Gell, who promptly sent back the humans' image. Then he sent another image showing more stars and another showing even more.

He continued increasing the number of stars and sending images until he reached the limit of his visual magnitude.

The AI told the other humans that the alien was more sensitive to dim light than the humans, but not by much: "It is as if our eyes were four times their maximum diameter, about 3 magnitudes more sensitive. We now know they are more sensitive than we, but we don't know whether they can see colors at that or any other magnitude. Unmodified humans cannot see dim colors. We do not know in what frequencies they see."

He sent more images, each showing more stars, and stopped at what a human would see from Ulterius. That meant he did not show too many stars. These images showed the stars as a two dimensional projection from one side of the galaxy, from what humans called 'Galactic North'. The brightnesses did not fit the projection.

The images showed a volume that extended beyond the Ulterius and Xi Bootis systems by a half the distance between them, and the same distance to either side to the line between them. The images included the stars above and below to the same distance as those on the side.

Then he showed a line between one dot, which to the AI and the other humans stood for Ulterius's sun and another, which stood for Xi Bootis. It was labelled with two sets of numbers, one in human symbols that gave the distance in meters, a big number, a dozen plus four digits, and another number in the alien symbols that gave the distance in their unit of measure.

Fortunately for the humans, Gell understood immediately what was going on. The humans had figured out that he came from Xi Bootis. The distances were right. He was interested to see many zeros in the numbers. Obviously, their measurements of interstellar distances were no better than his and they indicated that by rounding off.

Then the humans transmitted a picture of a second interstellar space ship. The second space ship was little different from the aliens' interstellar space ship.

The humans sent another image. This one was smaller; it held a larger volume and showed the space to Xi Bootis at the same time it showed another volume in the other direction. Yet another image showed a line to a particular star but without the measurement numbers beside the line.

That image had an image of the alien interstellar space ship beside the line coming from Xi Bootis and an image of the second space ship by the other line.

Gell figured out that the humans were telling him they came from the other star, similar to the way he had come from Xi Bootis. He quickly transmitted a copy of the picture back with the measurements added. He hoped that would tell the humans he understood. He gave numbers

for the measurements to the Melian star with the same precision as those shown on the measurements to Xi Bootis.

The new star was only about three-quarters as far away as Xi Bootis.

He did not know that the humans' AI had said, "While we have given away the location of Melior, we have not mentioned Farhaven or Earth. Although I don't think that locations much matter, I am cautious." Gell thought Melior was the humans' home planet.

Next, the humans transmitted an image of the current stellar system with all the major planets, including the Jovian planet, Nebber, in their current places.

Then it transmitted an image showing the Jovian one-half a twelfth of the way further around its orbit, an second image showing it a twelfth of the way further around, and yet another. Gell understood by the fourth image; the humans were trying to convey the notion of time. He rapidly produced more images, each with all the planets in their projected places — the inner planets moved quickly and the two bright outer planets moved slowly. After one revolution of the Jovian around the central star, the alien placed a number one beside it. After a second revolution, he placed a number two.

The humans immediately understood. The symbols for a fraction of time had not yet been communicated. They sent an image of the present with a zero beside the Jovian, then another one-half a twelfth later, with a fractional symbol in the alien symbols.

Then they sent a third image of the planets' locations a twelfth of a Jovian orbital period after the present with time marked in both symbol sets.

Gell figured this out. He sent an image of the projected places of planets for the next time unit, three one-double-twelfth of a Jovian orbital period.

The humans then showed two more images, each one-double-twelfth more time in the future and each labelled. Gell then showed two more.

Then the humans transmitted an image one-double-twelfth before the present, showing human symbols with an curious horizontal mark before them. The image did not show any alien symbols.

Gell and Rill said simultaneously, "That is their past time sign." "It may be their negative sign, too," said Gell. They sent three images to the humans.

The first was a copy of the humans' image, but with alien numbers, including a negative sign which the aliens also used for past times. The negative sign looked to the humans like a zig-zagging, backward 'S,' a 'Z.' Then Gell sent two more images of progressively older times with both human numbers and his numbers.

The humans replied by transmitting an image of the planets a Jovian orbital period before, with the base twelve and the base double-dozen negative numbers for one beside it, then another for two orbital periods before.

Then they transmitted an image of the planetary alignments fewer than half a double-dozen Jovian orbital periods before — the time label matched the planetary positions — and showed an image with the human interstellar space ship (very large in the image, of course) a little beyond the system in the direction of the humans' star.

Gell figured this out. "That is when they arrived," he said. He thought all the immigrant humans had arrived at that time, but none had; only Aglar's twin had come with the first terraforming robots.

Gell sent an image of the planets locations and the time that his space ship entered the system. It was only a short time before.

Then he sent the image of Xi Bootis and this system with the line between them, but with a picture of his space ship by Xi Bootis with numbers indicating the date he left.

The humans showed they understood by sending three more images with the alien space ship closer and closer to the Ulterius star and with appropriate times. Then they answered Gell's implicit question and indicated when the human space ship first left its home system. The speeds of the two different space ships were very similar, both about one-quarter light speed. Gell guessed that the two technologies, which looked the same, were the same.

The humans then sent an image continuing the line from the position of their space ship outside the system to the central star, showing the positions of the planets when it got near the central star, and telling the time in numbers. The times suggested an appropriate deceleration. Then another image showed a line from the central star to an inner planet, with locations and times that also made sense.

Gell decided that the humans came to an inner planet. That was why this system's Jovian planet was still dead. But he had a hard time believing the humans could live on a planet with such a low gravity and a near vacuum on its the surface. Worse, it did not have a strong magnetic field. He could not figure how they got off the planet.

Gell said that and Rill agreed. "But," said Rill, "aliens are alien. They are supposed to be strange. Maybe they really did come from a tiny, close-in planet with its non-living solids, its weak magnetic field, and its low pressure surface gas. They are creatures of the vacuum. That is what the images suggest. That is what the continuing deadness of the Jovian suggests. The circumstances are very weird."

At the same time, but in a different place, the humans' AI spoke. "We still don't know what the alien looks like, what his normal height is — I presume he was been downloaded into that small interstellar

vehicle, just like us. I bet he is still embedded although now that he is here, he is awake; or else we are communicating with their equivalent of a human-made AI. We don't know the environment of the aliens' home. What is natural? The environment must be strange. The alien space ship is headed towards a Jovian planet and I presume is from one."

The computer went on, "I think it is time for one of us — one in human shape — to go outside. That person should wear a space suit; there is no reason to confuse the alien with the notion that we are robots or in robot bodies. Not yet." He paused. Djem figured the halt was more for the audience than himself. Djem could not imagine that the AI had not yet thought through the notion or forgot what he had thought.

The AI started again. "We can transmit a sequence of pictures to indicate what we plan to do. That sequence should include a meter measure and his measure. The alien won't be able to show in reality — at least I don't expect him to be able to show a corresponding alien life form, but he can show a picture, along with measures."

Aglar Ivden stopped for a moment. Only three organically born humans were in humanoid bodies, Djem, Leestel, and Djaeds. He said, "Leestel, you should do it."

Gell understood the images; they were intended to show what humans were like. Still, he thought the humans intended to send a robot outside their space ship. He could not imagine that they lived in such a near vacuum that protected organics could survive without requiring a hugely massive pressure container. He was right to think that the bodies in spacesuits were not organic, and that no organic humans yet lived on Ulterius, but he was right for the wrong reasons.

Not that it mattered. As Gell saw, the organic humans were a little shorter than his people, but not by much.

What was different was the way the humans split their tail. They were not fins. The humans could not swim, at least not well. Indeed, based on the images, the humans looked as if they attached themselves to solid objects and moved on them.

Rill spoke, "The humans appear to live in the interface between solids and a near-vacuum gas. They are always stuck to a gravitating solid. Suppose that appearance is accurate? The humans do not live in a regular planet like ours. They live on a small, inner planet. If they live at the interface between solids and a near-vacuum gas, they and everthing else will always feel gravity. They do not swim because they cannot. They move around in some other way. They are very, very strange." 'He is right,' thought Gell, 'they are alien.'

Gell could not make an entity similar to the humans', since he did not yet have the mass; but he could send images with measures.

At the same time, Djem became decidedly undiplomatic. He feared they would never understand the aliens. "Suppose the aliens are as

Tuppak suggests, floating and swimming in a very high pressure atmosphere. That is what you would expect on a Jovian at liquid water depths. How could they understand us and we understand them?"

Leestel wanted to continue. She wanted to go outside. Telren said, "They are here. As Leestel said they are going to impact us regardless. We had better learn as much as we can."

Djem subsided. Telren's point did not mean they would necessarily learn much, but he was right, any learning helped.

Leestel came out of the humans' space ship. She carried a meter stick and another stick the length of an alien unit as well as a large rectangle, which she put aside. The meter stick had marks and numbers beside them with fractions in twelfths. The alien measuring stick also had marks. Its numbers and fractions were in base double-dozen. They were vertical and just below their related marks.

As a greeting, and to show she was harmless, she raised one arm, palm facing out. The aliens had no idea what she intended. They did not know that some human cultures humans employed the action to ward off a magical evil and others to indicate the person was not carrying a dagger.

Then Leestel illustrated walking, turning around slowly, and carrying the measuring sticks. The aliens understood. Leestel did not require prompting: even though a long time in her life had passed, she remembered her first contact protocols vividly.

The aliens saw that the human had five appendages, two long ones, two medium length ones, and a short one on top. The last did not bend in multiple places. That number suggested a base five system rather than a base twelve system. Two appendages, those used for carrying the measuring sticks, each subdivided into five more smaller appendages. Their existence pushed the creature even more towards base five or to its double.

But only one of the smaller appendages opposed the others so the creature could grip the sticks. That was awkward. However, on each side it left four other appendages. Four is one-third of twelve. Five would have made a very poor base, even double that would have made a poor base. So would four. But three fours would provide a good base.

Two fours or four fours would not be so good. As far as Gell could conceive, twelve was the smallest number that would succeed. The next smallest number made for his base. Twelve had two, three, four, and six as divisors. Five did not have any. Double five only had two divisors. Double four only had two and quadruple four only had three divisors. None of them were a third or a sixth. Of the small numbers, twelve was best.

Gell transmitted an image showing line drawings of one of his people from the front, the back, the two sides, and the bottom, along with measuring sticks.

The alien looked like a streamlined fish with fins and stalks. When looked at from one side, all the appendages, the fins and stalks, sat on a line in the middle. So did two markings between the visible stalk and middle fin. At first, the humans were not sure which end was the front and which was the rear. They figured the stalks, which were closer to one end than the other, held sensors of some sort and then they saw what was clearly a mouth at the same end. The alien had two moderately long fins on either side of the mouth. Each fin narrowed where it attached and became wider farther from the body.

Each front fin — the end with the mouth — divided deeply into two and the tips of each part divided again, although less deeply. Next came the stalks. Between them and the middle fins were circular marks. They were not too big. Then came the wide and stubby middle fins. Two more fins marked the rear. There was not much room between them, although there was some, along with another fairly faint mark. The humans decided that end had to be the tail. Its fins were longer than those in front, but not so deeply divided.

The creature in front of the human space ship moved the large rectangle so it was visible both from Gell's space ship and the front of the creature and then it showed images of what Gell sent! Gell understood. It was another display screen, this one controlled by the human, unlike the other, which was controlled by non-human robots.

Then, before Gell could do anything, the screen switched. The human space ship transmitted a series of images, each almost like the previous, but not exactly the same. At the same time, the images appeared on the human's screen. They were clearly images of the human walking, turning, and picking up the measuring sticks. They repeated and the creature copied them by similarly walking, turning and picking up the measuring sticks. Gell understood. The aliens were introducing moving pictures.

He quickly sent a speeded up, moving image of the Jovian planet, along with the positions of the planets and the time from the planets' present positions. He wanted the humans to understand that his moving image was speeded up.

He could and did have his computer immediately make line drawings which showed the wavy lines and spots on it. As part of the larger picture, he included, in a marked off segment, a still picture of one of his people from the side. The little image was intended to convey 'wait'. He hoped the humans would understand.

Gell had moving images of a swimming person, but his computer needed to remove the background and convert the images to a single

color and to lines. The conversion did not take long, but it took a moment. When it was done, Gell transmitted the images. He did not send anything telling time. First, he sent only a double dozen frames.

That was enough. Again, the human showed his images on her display. Then she showed the human kneeling down and rising up from what Gell decided had to be a solid surface, just as she had done before.

Next the human showed images of the human picking up and grasping the measuring sticks. Gell had anticipated this. He transmitted a moving image of one of his people grasping a measuring stick. First an alien grasped the stick with both forefins, then with one of them.

Gell made his image bigger and bigger until only the front part of the alien showed in the image. It clearly showed one forefin folding out of the way and the other grasping the measuring stick. The second fin folded itself lengthwise so two lobes could bend around it from one side and two other lobes could bend around it from the other side.

Almost immediately, the humans indicated that they understood. They transmitted a moving picture of a human hand grasping a stick. The image did not go to the edge of the display, as the aliens' had. Instead, the lines marking the arm stopped before it got to a bend. "Obviously," Gell said to the others, "we are seeing yet another convention. Fortunately, it is similar to ours."

The hand did not appear to be in a space suit. In the grasp, four smaller appendages that bent around the stick were attached to a solid body. The smaller appendages looked as if each was composed of three elements beyond the main body. The four smaller appendages were composed of twelve elements in total. The other appendage, which looked to be divided into only two elements, curled around the front of the stick.

Meanwhile, Tuppak Nassik told the other humans that the alien image not only explained their base double-dozen numerical system, but explained the strange mirroring of their numbers, too.

He pointed at the image from below the alien, although he did not know whether the image was from below or above. "As you can see, each alien has six fins, two in front, two in the middle, and two in the back. The front and back fins are longer than those in the middle. Each front fin is split dramatically into two pairs, and each pair is divided, although less dramatically. Each back fin is divided. When you look closely, you can see that each middle fin is divided into four lobes,too."

Several people indicated they agreed. They had noticed the indentations in the images.

Tuppak went on, "Combining that knowledge with the number system, we can see that the twirls or circles are used for numbers that correspond to the front or back fins. A circle must indicate the body. Its direction from the center of the symbol tells us which side the fin

is on. A fin on the right has the body to its left; low numbers have a circle on the left side of the symbol. Presumably, an alien counts from the front. It starts with the lobe closest to the center line of the body, the left most lobe, of the front right fin. Symbolically, a twirl or circle above the line indicates the front and one below the line indicates the back. I think that distinction is arbitrary."

Telren said, "Yes". No one could determine whether he was saying yes to the distinction or yes to everything. Tuppak said, "As for the middle fins, the body is indicated by a short vertical line. I would have expected it to be a horizontal line, except I think the horizontals show fins with vertical lobes."

Tuppak went on. "So the symbol for one consists of a circle on a horizontal line with a short vertical to the right. The symbol for eleven consists of three short verticals to the right of a circle that is below a horizontal line.

"We should expect symbols for numbers between twelve and twice-twelve to have their circles on the right; and they do! That makes enormous sense. Further, I suspect that originally the aliens counted down from a double-dozen — that is the source of the mirroring — but finally figured out that a dozen plus one really does come after a twelve.

"As for the symbol for zero," said Tuppak, "that consists of a body seen centrally from the back with no lobes marked. I presume it shows from the back; the circle is below the line. The aliens numerical symbols are very concrete." He thought for a moment and then said, "Maybe they are too concrete. Since twelve is on the right and the next number is on the left, it looks like the half way point between zero and a number that symbolizes a double dozen is twelve and a half, not simply twelve. And twelve and a half is equivalent to zero." He stopped again. "I wonder if any alien child is confused by that?" He asked without expecting an answer.

"Let me go beyond what we understand to produce a hypothesis we will be able to test. We already know that the number for two dozen must have two symbols, a one and a zero. That is as it should when the base is a double dozen. But I wonder whether an alternative symbol for two dozen consists of a horizontal line with a vertical stroke on the left and a circle on the right. That would parallel the symbol for one. At some point we can ask the aliens. I wonder whether initially, the number for two dozen marked the end of what could be counted. The aliens might know of an alternative number for two dozen but not know the latter idea. We can ask them about that, too."

Tuppak changed subject, but went on. "Since the aliens swim, they cannot be all that different in density from the substance around them. A little difference does not matter, but a big difference means they float or sink."

Leestel nodded. She knew about swimming under water after exhaling all her air. She sank. Tuppak said more. "We don't know their density, but it cannot be much more than two or much less than a half that of water. Maybe with bladders that fill with lighter stuff you can bring it down to a quarter, but that is about the limit. That tells us the range of pressures."

Everyone looked at him. "Suppose the aliens' air density is the same as water and the gases are compressed to that density, so he can swim in them."

"Why should we presume water?" asked Djaeds. "Water is a good solute," said Tuppak. "It makes a better basis than the other possibilities."

"What about ammonia?" asked Djaeds.

"That is a possibility," said Tuppak, "but I think evolution would have occurred faster in liquid water because of its higher temperature. Also, hydrogen and nitrogen do not combine readily to produce ammonia, so they do not burn well. That means molecules that have hydrogen in them, the equivalent of carbohydrates in Earthly life, cannot be eaten to produce energy. You may be right; we don't know. But water is a good presumption.

"Nebber, this Jovian, tells the range of temperatures that correspond to liquid water pressures. These temperatures are warmer than the human range. We would think them as boiling. Because of the pressure, the water is still liquid. It is not too hot. On Earth a very long time ago we learned of bacteria that thrive at those temperatures and pressures. Under these conditions, organic life can live and evolve."

He paused for a moment. "How they got off their home planet in the first place — I don't know. Neither of our AIs, neither Aglar nor Adkel, can figure it out either. The escape velocity is too high. Chemical fuels simply lack the energy. As far as I can see, the aliens need a nuclear rocket that not only provides a high exhaust velocity, but high thrust as well. We don't have anything like that."

Second Decision

In the convoluted but normal way of humans, going from what they don't have to what they do have, the question about how the aliens got off their home planet led to the humans second major decision.

Aglar Ivden loved humans. Even though he was an AI, he thought of himself as an improved version of humans, not as different. He feared that the aliens would learn too much human knowledge, that they would gain an advantage.

He feared that the aliens would learn about Earth. They had assemblers; they could attack or merely threaten to hurt. "Suppose," he

said, “the aliens do not come from Xi Bootis? Then our counter-threat fails; we will not know what planet to deter.”

Telren Dowwen opposed him. The human in a babbo body enjoyed enormous zeal. He wanted to continue learning from the aliens. He figured that only with trade — trade of ideas, mostly — could the two sides progress. As he said, “Humans can learn from aliens and the aliens will learn from humans. This is a way for us to provide knowledge and interest during our future.”

Djaeds Summervil settled the issue of threats and counter-threats. He pointed out, “Over the next few years, the aliens will learn important matters. ‘Willy-nilly’ is the term Leestel used. She is right.”

Leestel nodded; she had come back in from outside and removed her suit even though she was in a mechanical body and had no organic needs.

Djaeds continued, “Whether we want them to or not, they will learn. Interstellar space ships are coming from Farhaven and Earth; the aliens will learn from them.” This was the same argument that Leestel had made against him earlier. Djaeds had been impressed with the argument and decided there was nothing humans could do. So rather than protect humanity, his goal was to preserve it.

Aglar was not sure whether the aliens would bother to build enough sensors to detect humans’ interstellar space ships. “After all,” as he said, “we would not have detected the aliens’ space ship except that we had built a very thick sensor net because of a fear of Earth.” Aglar did not have to remind Djaeds that, in part, that fear was a result of his actions, erroneous in one way, but useful in another.

Djaeds was not sure whether the aliens would build enough sensors either, but said, “Even if the aliens fail to detect incoming space ships, they will learn people’s histories. Right? Humans will talk.”

Aglar agreed, the strangers would tell their histories not only to the other humans, but to the aliens. Djaeds immediately responded by asking whether Aglar planned to censor and modify every interchange forever. “After all, the goal would be to avoid disclosing the existence of Farhaven and Earth.”

He went on. “We need to think like soldiers in a modern, asymmetrical war: do not tell an enemy how to make toxic chemicals or bio-weapons or how to damage an inorganic mind. Do not mention any feature lacking resiliency. Without resiliency, constructs are weak. We need to preserve humanity.”

He stopped for a moment and then spoke with emphasis, “The rest does not matter. Indeed, whatever you say may have an unexpected but beneficial influence.”

Chapter 7

It became clear that the aliens were going to use more of the system's interplanetary resources, those that floated in space and were easy to access. They might actually change Nebber, the Jovian planet, more; they might change it in deep and irreversible ways, but to the humans that was irrelevant.

The interplanetary issue had come up before, but not been talked through. From Ulterius orbit, and in a reversal of his normal stance, Adkel Ivden made the long term argument. "How can we provide for the future," he asked, "when we give up resources?"

Leestel simply did not see how anyone could run out of resources. "There are vast masses of rock floating around this system. Even in a huge number of years, we humans will not have used them all. And I doubt the aliens will have either. There simply is not that much to build. Besides, we can and doubtless will travel to other stellar systems that don't have aliens and are not interesting to them. We can do anything we want in those systems."

None expected that Tuppak Nassik would be the person who settled the matter; yet he did. He pointed out that if neither species sought too much material, they could compromise. "It means," he said, "the aliens must show self control; as must we." When he heard that, Djaeds nodded.

Tuppak continued without pause, "I hope the aliens are temperate and do accept restrictions. Potential inter-species disagreements are no different than quarrels between two groups of human. With assemblers, a military does not need more people. So both sides can restrict populations. With smaller populations, less material is needed."

He stopped for a second and then started again. "As far as I can see, fighting is the only alternative. Whatever the reason, I don't see how we could fight them successfully. We could not preserve all of us."

Partly because of hope, partly because neither Leestel nor Adkel (although the AI said nothing) could stomach fighting, and partly because none of the rest could see how to implement a victorious war, the humans accepted Tuppak's notion.

At that point, the humans could not talk with the aliens, not enough for a compromise; but the decision did prevent them starting a fight. The humans figured that eventually they would be able to converse with the aliens.

Chapter 8

Adkel transmitted his idea of a dictionary to Aglar who did not suffer a speed of light delay. Aglar spoke, giving credit to Adkel, "We have numbers, moving pictures, a distance measure, and a time measure. We can speed the development of communications by transmitting to the aliens a dictionary with pointed to and pantomimed definitions."

"What do you mean, a dictionary?" asked Telren.

"I mean items that can be pictured, a simple dictionary. We can, as it were, point to each item and then say or spell the word that stands for the picture. The dictionary should include entries we can pantomime, like running."

"Well, maybe," said Telren.

"We just have to ensure the aliens understand the concept of dictionary; after that, with its moving pictures and what not, the document can stand on its own. At this stage it cannot be a human-to-human dictionary, that won't work. But later we can transmit regular dictionaries and encyclopedias. Then we can transmit books, music, and graphic art."

"What about the reverse?" asked Djaeds. "That would be good, too," said Aglar. "But they may not want to or they may not think of it. I don't think they have thought about First Contact as much as we."

Aglar continued. "They probably do not look as far into the future as we. Leestel made a strong argument, that 'it is better they enjoy good first memories than bad.' I am convinced by it. That applies equally to us. We should enjoy good first memories, too."

"Yes," said Djem, "So they should tell us. But maybe none of them have thought of it."

"That could pose problems for us," said Djaeds. "Yes, it could," said Djem. "But in the meantime, we should produce a dictionary. When we give them one, we may inspire the reverse."

To select the first items, they all, especially the AIs, looked at children's books and dictionaries.

Then they transmitted the dictionary to the aliens. At the speed of the connection, inefficient as it was, the transmission did not take long. To make sure the aliens understood the general concept, Leestel pointed to static images in the dictionary and then to the objects themselves. The objects were bigger than the images, had different looks, but the edges were similar and they possessed the same shape.

For motion, Leestel went out of the spaceship again and pantomined. She needed to show only a few things, like grasping and walking.

The aliens caught on quickly. They sent a moving image showing the edges of a human walking on a grid of triangles — "triangles fill an area, mark the ground, and have one less side than squares," said Tuppak — and then beside it, an alien that looked as if it were swimming above a grid of triangles.

"That is the parallel," said several people at once. Aglar almost immediately generated a running human. The human moved over triangles faster than before and ran with a slightly different gait than when he walked. In a image to the side of the first, he showed an alien swimming faster. Otherwise, however, it looked the same as before. Besides showing it on the external view screen, where both Leestel and the alien could see it, he transmitted it.

The aliens sent back similar images, but with the alien moving in the picture slightly differently. Djaeds Summervil commented. "Like running is for humans, the alien's high speed swimming gait is different from their slow speed gait. It is not much different, though. It looks less than the difference between walking and running." The others nodded.

Aglar, the human artificial intelligence, morphed the display by changing the triangles in the grid to squares, but left everything else the same. The alien promptly sent back the same image and then converted the squares to hexagons.

Next Aglar made the hexagons mark a rougher surface. He had the lines that made them move up and down about half the diameter of a hexagon. Every so often, the human's feet touched the lines, but most often, they touched an extrapolation of the location of the surface.

Then, as new hexagons kept appearing at the left of the screen, towards which the image was running, but never reaching, the 'ground' as it were, appeared to rise. The image ran up the hill but slowed.

The aliens sent an image of a different hill; it had a longer ridge. The swimmer moved serenely over it.

The human images told Gell, Rill, and the rest how dependent the humans were on stickiness. They lived in a gravitational field and were not immersed in a buoyant fluid. As Gell said, "At home, we live both in a gravitational field and in a buoyant fluid. Buoyancy is the difference." The humans, they thought, were very strange.

Meanwhile, Aglar said, "After we are sure the aliens understand the dictionary, we can send an encyclopedia. They are very like humans."

When the humans showed the moving images of a bending hinge, the parts rigid, the aliens showed bending in a single object, none of which was rigid. It looked as if the dictionary succeeded.

Moreover, the humans had included the glyphs for spelling each word shown. The aliens translated sentences such as 'the human runs towards the hill' into images of a human running towards a rise. Then they showed an image of an alien swimming over a hill that looked exactly

the same and wrote, in the human script, left to right, 'the alien swims over the hill.' Clearly, the aliens understood writing.

Moreover, the aliens had captured the notions of 'towards' and 'over,' both of which were independent words in some human languages and connected to words or part of them in other languages. The humans did not yet know whether the aliens understood the difference among specific and general instances, or the names of some of them, or simply repeated words.

The aliens understood the notion of a road — a smooth surface on which people could walk or run faster than on a rough surface — but baulked at the sentence, 'the road runs to the hill'. Instead, they showed two images, one of a running human and the other of a non-moving road.

"Literally speaking, roads cannot run," said Tuppak. "That is an anthropomorphism."

"It is not an anthropomorphism, which is only a human metaphor, but applies to any runner," said Leestel.

"That's true," said Tuppak, "but the notion applies only to runners."

Beside the sentence, 'the road runs to the hill,' the alien put a mark. "That either indicates 'no' or it indicates confusion." said Djaeds. "I think it indicates confusion," said Tuppak. "but I am not sure; maybe it indicates 'no.' "

He wrinkled his nose. "He put the indicator to the right of the human sentence, not above or below it. Either the alien has the same conventions we do for putting parallels and comments at the same level or he has figured us out. That does not matter."

Tuppak looked at Aglar and said, "Let's see, please make part of an image show a non-moving alien below the surface of the ground. That alien cannot swim to the hill. Put an empty space beside it for an indicator. Put that empty space at the same level and to the right, so it looks like the symbol-holding of the alien, but with nothing in it."

Aglar said, "All the space below ground is unmarked."

"My mistake," said Tuppak. "Please put a non-moving alien in that spot with enough room to the right for a mark. It is going to be harder for the alien to understand, but that is a risk we take."

"I could put a moving, swimming alien in the picture above the ground," Aglar said.

"That is a good idea. It should help. Please do so" said Tuppak.

"In another part of that same image, best below the first picture — you can put a line between the two pictures — show the sentence about the road with the alien's indicator beside it. If the alien responds with the same indicator in the first box, it must mean 'not'. If he responds with a different indicator, the second means 'not' and the first indicates confusion. If he does neither, he is confused."

"Yes," said Aglar. "We will see. I will display those images."

He did. At first, there was no response from the aliens. Djem had time to realize that he thought there were a number of them and Tuppak spoke as if there was only one in the Ulterius system.

Then the alien sent a still picture of one of his people from the side. Aglar said immediately, "That image came while we waited for a more complex image. I think it means 'wait.' I bet the aliens are trying to figure out what we mean. I would not put too much confidence in the result, what ever it might be."

Then an image came with a different symbol beside the underground swimmer than beside the confusing sentence.

Aglar sent an image with two pictures separated by one horizontal line. The top picture consisted of a moving human on and over the ground, marked by hexagons, so the view point was a little above. It included an empty space to its right. The second picture consisted of a frozen human under the hexagons, which again were seen from a view point above them at about a human's eye level. Space beside and to the right of the unmoving human showed what the humans imagined was the aliens' 'not' symbol,

The aliens promptly returned another signal. The empty space beside the image of the human on and over the ground contained another symbol. The humans decided that symbol must indicate 'yes'.

The humans, or rather Aglar, quickly produced another moving image with four parts, the two on the right empty. The top left hand part contained an image of a human walking to the hill. The bottom left hand part contained a moving image of a tree going to the hill.

The aliens sent back the same image as the humans, but with the right parts filled. The top contained the symbol for 'yes,' the bottom for 'no.'

"Hah," said Tuppak. "We now know that the alien understands plants. He understands that they do not move, or at least he understands that trees do not walk, but humans do. Also, he recognized that our tree is a plant. He saw that in the dictionary, since we did not tell him of them directly."

The humans decided that the aliens understood the purpose of the dictionary, the encyclopedias, and the literature. They matched images and symbols. The aliens understood sentences, which meant they understood grammar.

Not only could they understand simple sentences, like 'The dog runs to the rock,' and 'The hinge squeaks in the wind,' but they could create relatively complex ones using what humans thought of as metaphors. They wrote, 'The atmosphere runs into holes,' using the word 'run'.

They also wrote, 'The atmosphere fills holes,' and put two 'yes' symbols beside it. "The double is for emphasis," said Tuppak; "it means the sentence is better, but the use of the word 'run' is acceptable."

However, the aliens kept putting their symbol for confusion beside the sentence, 'The road runs into the woods.'

Then they showed an image. First, it was a still picture of a road going into a woods. Then, a part of the road moved and transformed itself into a human who ran into the woods, along the rest of the road.

"I bet the alien is saying," said Tuppak, "that he can understand the sentence that 'The road runs into the woods,' but understanding takes time."

He directed Aglar to put a 'yes' indicator beside a moving image of the road transforming itself into a human. "That is the key part of this metaphor, that we have anthropomorphized a part of the road."

Then the aliens showed an image of a swimmer transforming itself into a human, but not a human they had shown. This human had straight tubes for legs, no genitals, a simplified head. "What on Earth?" asked Tuppak. "No, it is not on Earth," said Djem. "It looks more like the space suit that Leestel wares outside the spaceship. I bet it is a robot!" He looked at Aglar. "Can you create an image of the aliens' space ship moving ... no, we cannot indicate a moving alien space ship. Can you create an image of a moving alien and an alien robot that is unmoving, and then the alien stopping its motion and the robot moving?"

"Yes, I can do that," said Aglar. "Shall I? Also, were you asking a question, giving me a polite command, or both?"

"Please make the image. I was both asking a question and asking you to carry it out. I understand your point. We cannot presume the same contexts for humans as for aliens as we are different. But as you say, they are more or less like us. I think what the aliens are trying to say is that one of them wants to shift from that space ship of theirs to a robot of ours, presumably, to get a better body sense."

"Yes, that is what I think," said Aglar. At the same time, he started to produce the images.

The alien received it, and transmitted it back with a 'yes' symbol beside it. Then the alien showed the robot entering the human space ship, the space ship becoming smaller and smaller and smaller. Next, it showed an image of the stellar system, like those that had been exchanged before. The image showed a dot at their location. Then the dot moved, with a line behind. Everything else moved, too, all the planets. The dot was the human space ship. It took an appropriate amount of time to go to the human planet. Then it showed the robot and humans walking around.

Chapter 9

"It is a request to visit," said Leestel, "the alien visiting our planet!" "Yes," said various others. "I think we should help," said Tuppak. "Obviously, the alien wants to learn more about us; that is fine. We should give him opportunities. He will learn more of our context. Roads do not exist on any Jovian; maybe he will grasp the idea of a 'road running into the woods' better."

"We should visit the Jovian, too, in robot swimmers," said Djem, "but not immediately, since the planet currently has no life. We can always go down. And we can radio up differences, so getting back up physically is not important. After radioing, we can stop the minds of the robots down there."

"I can make an image of a swimmer," Aglar said, "that looks like a stiff alien, an alien robot. It will not look like a real robot, which has much more flexible skin. Interestingly, we all saw that the alien was putting himself into a humanoid robot, not an organic human body. I am not sure what to make of that, except that it means no human need concern himself; and it any case, we have not grown them yet."

Djem answered. "Do that. Also, please make images of us visiting them. Those images should include a human transforming into a robot swimmer and a swimmer flying above a landscape. Leave the timing aside; don't produce any images of this solar system. Don't say how we get down or how we leave. Let's see how they respond."

The aliens transmitted the pictures back with 'yes' symbols to the right. Then they showed an image of a swimmer flying above a landscape and another of the stellar system with the Jovian planet going around, the inner planets zipping around. The point of view pulled back. The inner planets' orbits got too small to show, the Jovian planet moved rapidly, and even the outer planets moved. Finally, all stopped.

"That is a gross of terrestrial years in the future," Aglar said. "I am not surprised," said Tuppak. "Patience is a virtue. We have been terraforming here nearly a gross of years already. Our changes are fast compared to natural processes, but slow in human terms."

"We do not have organic bodies, yet," Aglar reminded them. "That is why you are all in robot bodies."

"I don't think that will matter," said Tuppak. "If we appear in robot bodies, the alien will figure we are being both polite and safe. We can show pictures of what Ulterius was like before terraforming — the alien might appreciate that it too was a dead planet, like the Jovian planet, Nebber. We can show the time we started, too. That is about as far back in the past as the alien is showing for the future; so the alien should understand, we are nearly ready for people, but not yet."

"What about us?" asked Telren. "The alien, or very likely, there is more than one awake, if you look at the other space ships — he or they will probably figure we are like them, early birds, living in robot bodies."

"We do not have to tell him that terraforming takes only one AI," said Aglar, "who slows down much of the time."

"Yes," said Tuppak, "most of terraforming is boring. I remember Eltis once saying, 'it is not *like* watching the grass grow, it *is* watching the grass grow.' I am sure that transforming the Jovian will be just as boring. Once the planet is seeded, which could be done by ships controlled by reasonably intelligent computers, everyone should slow down again. Maybe there is only one alien or one alien AI talking to us. He may be carrying the data packs for a million more, but none have been woken yet.

"Indeed, to wake any out here would require thick hulls." Tuppak went on, "That is if they are going into organic bodies. The pressure is five gross more than we are accustomed to. Robots are better." He nodded. Then he said, "I still have not figured out how they got off their Jovian in the first place. Orbital velocity is really high." The others shook their heads. Aglar said, "No one has figured that out. That is a mystery."

The aliens started transmitting again. The humans saw words, 'alien visit planet' and an empty box to its right.

Leestel said, "It is checking that its sentence is right."

"Perhaps it is checking that the underlying notion is acceptable," said Djem.

"This message is a poor discriminator; the alien did badly this time. But we can give an answer anyhow. Aglar, please respond, filling in the blank panel with a 'yes' symbol."

"Done," said Aglar.

Like all the interstellar spacemen, in case someone tried to steal or kidnap him, Gell had explosive in his inorganic mind. If he were kidnapped, he could be put into a mind without senses. After a short time of that, he knew, he would go mad. When the explosive was installed, no one thought it significant. No one expected to find another intelligent species. The police were simply being exceptionally careful. Now he hoped the humans were friendly.

Gell was being courageous, but it made sense. These aliens who lived in a solid/near-vacuum interface, who were not supported by a buoyant liquid and felt gravity themselves, they were really strange. He formally handed over his responsibilities to Rill, who understood that to mean that Gell was not at all sure he would come back.

"I am going to radio as much knowledge as I can," he said. "These crazy aliens have got here first. They have gone a long ways towards changing their planet and we have yet to begin."

Gell's transmission to Rill conveyed great seriousness. "I hope we do not have to fight them," Gell said. "They know where we came from. They could hurt us. We think we know where they came from, but maybe not. They have to wonder the same about us, so that is a deterrent, but still ... We are better off understanding as much as we can. As we expand, we will meet more aliens, although probabilistically speaking, they will be much more advanced or much more retarded than us or these aliens. I hope we can coexist peacefully."

This started a discussion among the alien pilots. Gell wanted to stop it, but he was too smart. Besides he had just transferred his formal position to Rill, and in theory could not impose anything on anyone. Rill spoke first, as was his right. "Both we and the humans need to follow limits." It never occurred to Rill that by speaking first, he was telling the others what more senior people had decided.

An alien named Voel felt more concern for his own people. He was not sure they should accept limits that permitted humans to exist. But he did not repond directly; instead, he said, "Whatever we do later, right now, we should learn as much as we can." That statement was very like the expression of the human, Telren.

Kael settled the matter. After expressing what was important to him but irrelevant to the decision, he repeated Leestel's argument to the humans, although he did not know that. He started out by saying, "Not merely do they exist in the same universe, they exist close by. It felt like one night's travel."

"It takes more than three double-dozen years to get here," said Gell, grumbling.

"I know that," said Kael. "However, from the point of view of the universe, we are close. The feeling is that it takes one night to travel here." He emphasized that it was an emotion. "That feeling is more accurate than the sense that we must go huge distances. I know we have to go a huge distance, but the universe is much, much bigger."

Then he restated Leestel's argument. "We cannot kill them all; we cannot be sure how many systems they have settled. Our species is going to meet other tool-using aliens sooner or later. We need to prepare. Our best solution is to be kind and generous. That will most likely evoke an acceptable response on their part. We can and should be careful — they probably have factions just as we do. But it is worthwhile to them to respond comfortably to us if we act comfortably to them. That is straightforward mathematics. It is foolish to think otherwise."

At first the humans thought Gell would transfer a duplicate of himself to the human's robot by radio. That could be done, although there

was a huge amount of data and it took time. You could not radio the data between stars in a reasonable time. That is why interstellar space ships existed. It was better to move the information in a solid.

The initial action and image were not confusing. Assemblers constructed a humanoid robot for the alien and put it outside. At the same time, a picture of the humanoid robot was put on the display and was transmitted. The aliens transmitted the picture back with a 'yes' glyph to its right to indicate, the humans hoped, that they understood.

The second part was not confusing, either. The humans created and broadcast a picture of the aliens' space ship and, a little distance away, a picture of their humanoid robot and their bigger space ship. The humans received that image and a 'yes' back from the aliens. Then the humans transmitted a picture of the aliens' space ship with a moving swimmer inside.

To indicate the swimmer was miniature — the alien interstellar space ship was small — the moving images started at the swimmer's normal size. Then the image of it became smaller so the swimmer fitted into the alien space ship. The swimmer shifted back and forth between being an original, presumably organic, and another that had straighter lines than the other and displayed less detail. This was the image of the robot.

The alien transmitted back a picture of a robot swimmer and a 'yes'.

The humans transmitted that image and send the words, 'robot swimmer'. The alien transmitted back 'yes'.

Next, the humans transmitted the image of their robot for the alien and the words 'humanoid robot for swimmer'. The alien transmitted back 'yes'.

The last part was confusing. The humans knew what they meant, but not the aliens. The humans transmitted a group of images: first, the humans showed a picture of the aliens' radio antennas that sent the signal home. Second, they showed an image of the source and destination, with the systems just as dots, a stellar map. Third, they showed a moving image of the Ulterius stellar system, but speeded up. First, the positions showed the past. When the positions corresponded to the present, the humans started a wavy signal from it that shortly appeared in the stellar map. They continued moving the Ulterius stellar system into the future. After one Jovian year, one Nebber year, the radio wave had almost but not quite reached half way. Then the humans stopped.

The alien responded by retransmitting the images with 'yes' glyphs beside each. Then he or they transmitted a continuation; they showed the Ulterius stellar system into the future and moved the radio wave, too. After just over another Jovian year, they stopped. They showed the radio wave as reaching Xi Bootis.

The humans retransmitted the final two images, the Ulterius stellar system in the future and the radio wave reaching Xi Bootis, with 'yes' glyphs. The aliens could not figure out why the humans presented any of this, but they went along with it. There had to be a purpose.

The humans then shifted. They transmitted images of the alien's robot, their humanoid robot, and the symbols for radio waves between the two. The humans did not show time at all.

The aliens retransmitted those images with a 'yes' glyph, and then retransmitted the images with a diagonal line drawn through them. None of the humans understood.

Then the humans saw the next pictures the aliens sent. Those pictures showed a little rectangle come out of a robot alien, who was outside the alien space ship. That robot stopped moving. The rectangle crossed the space between the alien robot and the humanoid robot and entered it. The humanoid robot started moving.

"The alien" said Tuppak, "wants to send a material object to us. It will then connect. That is harder than transmitting radio. Our space ship and their's are close enough for either. If we accept a material object, we will have to construct a new robot. Fortunately, that is easy and quick."

"With a solid object, they will discover more of our capabilities," said Aglar. "We will learn from them, too," said Leestel.

Tuppak nodded and then said, "Both are true. In any case, we have already learned that the diagonal line means 'no' or 'I don't want to.' The alien 'not' symbol goes part of the way; it does not go all the way."

"The alien requires a sense of control just like we do," said Aglar. "The sense need not be terribly rational, just the belief that he can try something."

"He may be able to radio differences," said Tuppak. "We do that to make back ups. But he cannot transmit differences until he is first there. He can get to us in a computer from which he can gather differences. The material object will enable him to find more about us. He may figure he is being very rational."

"I had not thought of him as thinking he is rational, but that might be," said Aglar. "In any case, we do not want to frighten him."

"No, we don't," said Tuppak, "Leave him an ability to escape in his own machine. He won't trust any of the equipment we provide. After all, from his point of view, we are the aliens and we are really weird. We don't even float in the atmosphere we breath . . ." He grinned.

"More immediately, we should make a picture that asks for a dead object. Then we should show it being investigated."

Aglar asked, "How about indicating that the computer or robot is dead by starting from a dead swimmer robot? We can show a dead

swimmer robot by showing one that is not moving. The dead computer should move out of it, towards us, and enter a large image of a square. In that square, we can show it being cut apart. Well, I can produce an image of a line coming out the side of the large image, touching the little robot and making it even smaller. We do not have to show how good we are, but if the little robot or computer vanishes, that is a pretty good suggestion that it is destroyed. Do you think that will work?"

"I think so," said Tuppak. "Try the transmission. If the alien sends us a living robot, we can always duplicate it."

Aglar already had a rectangular box with a recorder in it. Leestal moved it out of the human space ship. Aglar wrote 'wait' on the display and transmitted the word. The aliens responded by transmitting 'I wait' rather than a 'yes'. While setting up the recorder, Aglar changed the display to show the original symbols for 'wait' that the humans sent, a picture of the aliens' space ship saying 'I wait,' and a picture of the humans' space ship saying 'You wait.'

"If the alien says 'yes,' that does not tell us whether the alien knows his 'I', or at least, what we presume is an 'I,' or our 'you;' he may think of them as names. It is a step in the right direction, but that is all."

The alien transmitted 'yes'.

After setting up the recorder in its box, Aglar erased the 'wait' messages from the display and then showed the two spacecraft with a new rectangle on the human spacecraft. It had the right proportional size to be an image of the box with the recorder in it. The alien immediately signalled 'yes'.

Then Aglar showed a moving, swimming robot in the aliens' space ship along with a non-moving robot. A small rectangular object popped out of the non-moving robot, came across the space separating them in a straight line, and entered the larger image of the new rectangle.

At the same time the little rectangle in the display entered the box in the larger image, Aglar opened a real door facing the aliens on the box containing the recorder.

Again, the alien transmitted the glyph for 'yes' and then signalled 'you wait'. The human's signaled 'yes' and then transmitted a picture of their space ship with text saying 'I wait.' "If the aliens transmit a 'yes' that means they have sorted out 'I' and 'you," Aglar said. "I agree," said Tuppak.

The alien transmitted 'yes'.

A little while later, not very long later although Leestel had gone back into the human spaceship, manipulators on the aliens' space ship pulled an object from a dark hole. It was about the size of a human fist. It looked as if it carried as much mass as the original interstellar space ship. It had been constructed from one of the system's planetoids.

"That is larger than I expected," said Djem. "We can see it readily," said Tuppak, "and it may contain more than we expect. Also, the alien may not be showing us his full capabilities."

The object looked squared off. The space ship's manipulators turned it all around. They pulled and flapped what looked like little manipulators attached to the object, then put them back. The big manipulators then took a line with two prongs from the hull of the space ship and plugged the end into the little object. Immediately, several red lights on it went on.

"I am also picking up infrared lights," said Aglar. The others nodded. They were all in robot bodies without human limitations; they saw the infrared, too.

When the big manipulators pulled the two prongs from the little object, the lights went out.

"He is showing us the power source and telling us that the little robot is truly dead," said Tuppak. "That is what I think, too," said Aglar. Everyone else nodded.

Finally, the big manipulators on the alien space ship tossed the little object slowly towards the human space ship. Its path would take it through the door of the recorder.

"Well," said Djaeds, "it could disassemble us, but I don't think that is likely. I bet it is a dead robot."

The drifting object entered the door of the recorder, which closed. Shortly thereafter, the computer that read the outputs of the recorder said it was a dead robot, its general architecture was the same as humans robots, but its detailed architecture was different. It had sensors front and back; they could be drawn into the body or not. In addition it had manipulators, a built-in and fairly powerful radio transmitter and a sensitive receiver. It had simple power connections and a small helium three reactor. Also, it had connectors for sensors and manipulators.

"Hah," said the investigating computer. "The sensor and manipulator connections are insulated from the rest of the device, so an electric surge, at least a moderate surge, will not fry the rest. And if I apply power," it was working on a duplicate accurate to atoms, "those connections become live and transmit a repetitive signal that I bet tells us the protocols.

"Hmm . . ." the computer said 'hah' and 'hmm' like a human, even though its voice would not be confused with a human, whether organic or inorganic. The computer continued, "The object also has what looks to me like a small helium three reactor, just like ours, but turned off."

Tuppak raised an eyebrow, but did not say anything. "The physics is the same; the physics cannot be anything else. And the engineering embodiment must be similar," said Aglar. "That's true," said Tuppak.

"Also," the investigating computer continued, "we have a batch of connections separated from the others. Each batch has two dozen wires in it. There are two dozen sets." Everyone understood where those numbers came from. None spoke.

"The sets are in two groups, one group is closer to the sensors, the other is closer to the manipulators.

"Each wire shows a repetitive signal; its frequency varies a bit. Also, in each batch, each wire has a frequency band that is separate from the others. The wires closer to the front have a lower frequency band, those farther. An interface will not be hard."

Tuppak nodded. "The alien thought about this. I bet we can connect the connectors any way, and they will work. That is what I would do if I were putting a machine in the hands or other manipulators" — he smiled — "of someone very strange."

Aglar started putting up images of the insides of the object on the display and transmitting them to the alien. He showed each image in two dimensions, initially the part that first entered the recorder. No one thought it luck that that part contained the forward looking sensors.

The investigating computer went on, "The object has a second set of sensors by its rear; they are not extended like the front are, but they can be. Also, it has additional connectors on the other side of the body to the first. They parallel the first set. The object is symmetrical."

The visual sensors were like insect eyes; multitudes of little columns. They did not have lenses at all. Their sizes suggested the being could see from the green into the far infrared.

"Xi Bootis A component is a latter G type," said Tuppak, "whereas we are an early G. Its light is redder than ours. So their eyes' central sensitivity should be at a lower frequency. Nonetheless, I would not expect the creatures' eyes to be so shifted. Maybe something in their home atmosphere cuts out the blue." "We will find out," said Telren. "Eventually," said Tuppak.

"This robot has a multitude of sensor types," said the investigating computer. "However, at any given frequency, as indicated by the size of a column, no more than three types of sensor overlap. In other words, when we have the alien look through human-like eyes, he will have trichromatic vision like most humans."

On the screen and in his transmissions, Aglar displayed wires. He did not show the conductor and insulation as separate. Moreover, he did not differentiate the parts of the processor or memory although he showed where each was in the machine as a whole.

After showing all the slices of the object, he changed so as to show all the connectors. They were all on a single two-dimensional plane, another plane, a different slice, convenient for display. One double group was closer to the left and right sensors in front; two more groups were

closer to the manipulators on each side. The power holes were on the same plane, too.

In the image, Aglar showed prongs entering the power holes. Then, in an obviously slowed down animation, he showed signals coming from each of the other wires as wavy lines.

Then he showed a new wire from a connector close to manipulators on the right side going to a right hand arm of an obviously false-sized image of a humanoid robot. When the object's wire made a signal, the robot's arm moved.

The aliens transmitted 'yes'.

Next, Aglar showed a wire from a port near the sensors on the object to a sensor, an eye, on the image of the humanoid robot.

He stopped the signal sent through that particular wire, although he kept the power on and had such signals come out of the other wires. Then he started a signal at the robot's eye and had it travel slowly along the wire to the object. The signal was a different frequency than the wire had shown before, but within its band.

The aliens transmitted 'yes'.

Then the aliens transmitted images of their object moving from their space ship, going into the humanoid robot. The image always contained a wave between the object and the front of the aliens' space ship. That wave had become the convention for symbolizing a radio signal,

"Please transmit a 'yes,'" said Tuppak. "The alien wants to remain in radio contact all the time, perhaps to report on us. He does not trust us. I think he is really scared."

"He doesn't know about our abilities," said Leestel. "No, he doesn't," said Tuppak, "or he does and fears we will use them badly." Leestel looked disconcerted. "Remember," said Tuppak, "the alien does not know yet whether to trust us. He may come from a culture that focuses on winning and losing, on zero and negative sum situations, just as we come from one that focuses on win-win, on the benefits of cooperation, on positive sum situations. We don't know."

"He is being cooperative," said Leestel. "That is true," said Tuppak, "but at the moment, the alien does not have much choice. From his point of view, we are an 'out of context problem.' He does not know what we can do. If he or his people plan to betray us later, he needs to gather information now. And if he plans to cooperate later, he still needs to gather information now. We don't know what he plans, any more than he knows what we plan."

"We are going to be cooperative," said Leestel. "That is the probability," said Tuppak, "but we don't know for sure. We cannot predict the future."

Djaeds interrupted and asked a more pressing question, “What about radio shielding when he is inside our space ship?”

“Doubtless, the alien’s receiver is sensitive enough to pick up the weak signal that will get through, at least when it is close by.” Tuppak stopped to think. “You have a good point,” he said. Djaeds looked pleased. Tuppak went on, “Perhaps the alien’s signal will become too weak. We can have its radio transmission picked up by our ship and retransmitted strongly.

“Aglar,” Tuppak directed his attention towards the AI robot, “can you make a display showing a radio transmission from him becoming weak as it passes through our walls, but goes on to the aliens’ space ship?”

Tuppak creased his forehead, which Djem had not realized could be done by a babbo-looking robot, “At the same time, can you show our ship picking up that transmission and rebroadcasting it?”

He thought for a moment longer. “I guess you need two waves coming from the object, one going straight to the aliens’ space ship and one going directly to the receiver inside our ship. I guess you can show the effect of our ship’s hull by showing the radio wave with one third its height outside as inside. Make our retransmission have twice the amplitude of the wave inside. The actual values don’t matter. The actual differences will be much more than that. And make sure the waves from our ship and from his object are in synchrony, in phase, when they reach his space ship.”

“I can do all that.” said Aglar. “It will look like this.” He showed a picture. Tuppak nodded. “That looks clear. We are fortunate they understand us so well.”

“. . . or give a simulacrum of understanding,” said Djaeds. “That is possible,” said Tuppak, “but we have to presume understanding, given that they must see us as strange beings who live on the surface of a rocky planet in what to them is a near vacuum.” Djaeds murmured a few words which everyone took to mean agreement. Tuppak looked at Aglar, “Please send that image,” he said.

“Will do,” said Aglar.

Almost immediately, the aliens signaled ‘yes.’

Gell felt the moment of action was upon him. He did not like it. He transferred himself to the small robot from his space ship — he definitely thought of it as ‘his’. Rill, who had been in a different body, transferred and took over.

The big manipulators took the small robot, the ‘small rectangular object’ as it had been pictured, and turned it over to show all parts. Gell waved his manipulators and blinked his lights to show he was live.

On the humans' space ship, manipulators turned the new humanoid robot so a hole in its back became visible. It was lit up on the inside. The hole was just the size of the alien object. Another brain could have controlled the humanoid robot so it could move itself, but the human AI, who was controlling all this, decided that it would be more diplomatic to have the humanoid robot stay unmoving until the alien made his connections and moved it himself. Besides, by showing the manipulators could reposition the humanoid robot, Aglar also showed he could catch the alien if he were not aimed precisely.

The alien manipulators threw Gell right. He came slowly towards the hole. Aglar noted that the speed was the same as that of the first object. Gell had time to look around. The view was no different than being in his own space ship, except he could see it. His space ship looked small and became smaller. When Gell got closer to the humanoid robot he folded his manipulators to his sides and pulled in his front sensors. He could still see. Indeed, he could see out of front and back sensors, just like on his space ship. But by pulling in his sensors, he reduced his angle of vision.

Just before he entered the hole, Gell saw that not only was it was lit up, it contained connectors that matched his, and that each group had an image of a part of a human body beside it. Some groups went with obvious images, like arms and hands; others were less obvious. But when Gell looked in the humans' dictionary, images corresponded. One was labeled 'stomach' and had to do with organic energy inputs. Gell could not figure out why this inorganic, robot body contained such a picture, but he put that aside.

Gell entered the hole. His vehicle was captured and slowed down to a stop with what felt like elastic pads. Wires touched his connectors. Signals came from the humanoid robot's front. The humanoid robot did not have any sensors on its back, or no visual sensors. There was a lot more coming in than Gell could analyse immediately. He radioed everything to his ship.

Chapter 10

Gell looked at the human space ship. He did not move anything yet; he decomposed the signal from the robot's right eye.

He knew roughly what to expect, since the human robot's visual sensors were pointing towards the ship. He looked at the image produced by the left eye. That signal came from the parallel set of connectors on the other side of his body. Other than the slight difference in position, the other eye showed the same image. The two together would produce close up binocular vision, just like his. The two dimensions of the humanoid robot's binocular vision would be in the same plane as his original vision and as the robot's manipulators.

'Ah,' Gell thought, 'instead of considering them as manipulators, I should think of them as hands. They are like mine, but not as good.' He had not been in an organic body for years and years, but he still considered that to be really his. He considered the interstellar space ship a possession. While he accepted the reason for Rill controlling it, he was not happy.

He thought of himself as an organic entity even though he had been embedded in an inorganic computer, and used its manipulators, for longer than he lived in an organic body. Of course, he had slowed down his thinking during the transit from one stellar system to another, but still, he had spent much time embedded.

He carefully sent a signal to another set of connectors to move the right arm. It twitched. That was good. Gell felt proud. He was controlling an alien device.

Soon, he had the right arm moving up and down. He had not done anything with its hand yet, or with the other appendages, but Gell thought that getting the arm moving was most critical. The joint away from the main part of the body permitted movement in only one plane. Gell remembered that the dictionary called it the 'elbow' joint. The 'shoulder' joint enabled movement in two planes. However, you could not bring the 'elbow' closer to the 'shoulder'. The two were a fixed distance apart. The dictionary said it all, but doing was different. Gell relished the experiments.

The humans did not interrupt.

The left arm took the same signals as the right. The movements were the same, except for being in a mirror.

Next, Gell worked on the right hand. He was not certain which wire controlled what, but by good luck, the first signal he sent controlled the first finger. The signal moved it up. He tried a number of signals to move it down. The hand twitched, but he could not move the finger. Finally, he found a different signal, on a different wire, to move it down. The rest was easier, since he had already sent many signals and observed

the results. One of the benefits of being embedded, Gell thought, was that the computer he was embedded in remembered everything.

Soon, he could flex the hand and grasp imaginary sticks. The left hand took the same signals as the right, except it, too, was in a mirror.

Next, he moved the right arm so the right hand could grasp a rod that had obviously been placed in position for just this purpose. The fingers went around the rod one way and the thumb another. Gell decided the grasp really was not as good as his natural grasp, just as he had thought before, but it was good enough.

Also, he picked up signals coming in from the hand. By varying the force of his grip, he decided the signals had to be pressure.

As for visual differences . . . he decided he had to move his eyes. They showed a high resolution central image and a low resolution off-axis image. The eyes had been pointed at his hands and the rod, but now he had to move them.

He paid attention to just one eye, found a wire that had no incoming signal and figured he should send an outbound one on it. The image immediately defocused. He was not accustomed to that. The eye really did have a lens. It lacked millions of columns, each going to a different sensor like his. The human eye was not unlike the eye of some of the lower animals on his home world. Fortunately, he was embedded. He knew that in an organic body he would not remember any of this; but in a computer he had no trouble recalling all the information that had been recorded, including information on focusing and defocusing lenses. It took a very brief moment to understand what was going on. By simply stopping his signal, he regained focus.

Then he tried another silent wire. The image scrolled left. That, he realized, must mean the eye had turned right. He tried more signals. He found he could move the eye left and right, up and down. He could not twist it.

He could even turn off the image, that is to say, he could make everything black. Initially, that scared him as much as defocusing. The humans' dictionary called it 'closing an eye'. By stopping the signal, he got his image back. In his organic body, or in his regular inorganic body, he never closed his eyes; he couldn't. He just paid more or less attention. He knew these creatures were weird, but they were weirder than he expected.

It was easy to merge the image from the other eye and produce binocular vision. He could duplicate its aim. The two eyes were on the left and right, but was not as separated as his. These humans did not have practical bodies.

With his eyes able to move, he turned them to an image of a spectrum. Gell admired the humans for thinking of it. He would have forgot. The spectrum showed colors from below his frequency range to

above it. The display included the most vivid spectral lines. The double sodium lines were visible. They had fractional numbers beside them, a pair beside each line. One of each pair consisted of his numbers; the other consisted of the humans'. The one in his numerical system gave the right wavelength for the lines. When he converted to the human's measure and numbers, it all fit. The indicated wavelengths of the other spectral lines fit, too.

With the robot's human-like eyes, he saw a higher frequency, a shorter wavelength than normal. That was a benefit of humans. But the frequency of the lower visual cutoff was less than an octave below that of the top cutoff.

Gell realized that he was getting frequency information from only three types of sensor. A fourth sensor provided low resolution images to the sides of what he was looking at; that sensor did not distinguish among colors. As he could determine by moving a hand, that sensor was sensitive to movement. He did not know it was also more sensitive to dimmer light or that the two kinds of sensor overlapped with the type more sensitive to dim light farther away from the center than the type that detected colors.

Actually, human eyes, Gell decided, were not that different from regular eyes. Gell thought of his species eyes as regular, but then it occurred to him that maybe the humans thought of their eyes as 'regular.' Humans might consider his native eyes as 'insect-like.' In any event, both had a lower resolution away from the center. But humans could not see many colors. Human vision was very limited.

Before Gell had a chance to move his legs, the humans started displaying again. In the moving image, they showed him pulling himself along rods and entering the space ship as he expected. He went through two doors, which he did not comprehend, and entered a room with six independent entities in it. Two entities walked on four or sometimes six legs. None of the entities looked organic.

Then the display showed small rectangular objects, like his own robot, going from what looked like human robots to these entities. When the small rectangular objects left the first robots, they stopped moving, and when the entered the second set, those started moving. He transmitted 'yes'.

Humanoid robots provided the small rectangular objects that entered both the entities that walked on more than two legs. 'Perhaps,' Gell thought, 'the humans are trying to find a creature more like me that succeeds in a gravitating, non-buoyant, solid/near-vacuum interface.'

On further study, each of the two-legged robots looked slightly different from one another, as did the two others. Gell would be able to tell them apart by vision.

His body, now that he considered it, was slightly different, too. It looked very much like those pictured. Its parts fit the averages of the others, more or less — its height fit the mean, as did the lengths of arms and legs. Gell presumed he got a standard model. It would be slightly different from the individual models of each of the humans, but not that much different.

Gell wondered whether the humans could produce organic bodies and were being polite in having robots, or could only produce robots. Perhaps, like his people, the humans could do only the latter, but he would act as if they were being polite.

Meanwhile, he wondered how the humans planned to get off the inner planet they were going to. He desperately wanted to return to his space ship and could not imagine any other conveyance than physically transporting himself.

He knew how to get on to it: an aerobody would work fine, even in the near vacuum of the inner planet. Even less air was enough.

But how to get off: that was another question. The planet did not have the strong natural magnetic field that enabled his people, with enough electric input, to accelerate vehicles half way around the world. For sure, the humans' answer was in their dictionary or encyclopedias, but Gell was not sure whether what he saw would be right.

The humans had come from an inner, rocky planet. It had an atmosphere, albeit a thin one, so the humans could not use an artificial magnetospheric plasma, like he and they used in space. Moreover, Gell did not think that any rocky planet could produce the powerful, natural magnetic field that an electric accelerator required. So the humans must have used something else.

Regardless, he was committed. Only his left foot was attached, in a very obvious manner, to what Gell was learning to call a 'floor'. That was a human word for an artificially produced, solid flatness on which gravitationally, or otherwise, attached entities could move. The humans' ship did not produce enough gravity to notice, so something else had to cause entities to stick. Gell thought that a magnetic or small mechanical option would prove better. He had not seen any large clamps in pictures. He had not moved, but he could see how it would work. That was its advantage. He also saw the rods that went from him to the door. The humans meant him to pull himself along those rods.

Gell found the set of wires that according to the image beside them belonged to the right leg. He found the connection that corresponded to one that sent signals to move the right arm from its ball joint and sent the same signal to the leg as he had sent to the arm. The leg moved forward. It was shaped differently from his arm, but not too differently.

Next, Gell learned how to bend forward. That was not hard: same signals, different connectors. With another set of connectors, he could

control the angle of his neck. That was useful. He and his people had no trouble in free fall, since they were shaped for swimming. But humans 'walked.' The default aiming for their eyes was a quarter turn away from the direction of their long axis. Gell decided the aim fit an entity 'walking' in a gas on a solid, but he could not see any sense in it for free fall or swimming. He would engage in the non-default action of tipping his head up when he needed to see where he was going as he pulled himself along the rods towards the door.

His long axis paralleled the human's space ship. He could see it with his eyes. Two rods about a human or humanoid body's width apart went from his robot's feet past his head and onwards. They both stayed away from space ship's surface a constant distance; then they curved and went towards the door.

Gell bent down and slowly unclamped his left foot. The left rod stopped by his head so he had no trouble bending down. He found a rod next to his foot and grasped that with his right hand. The motion was so small, the rest of him hardly moved in recoil. From there, he pulled himself to the door. To prevent himself drifting off, he merely had to make sure he always grasped a rod with one hand or the other. The door was open, as he expected. In it were more rods, but there was a space between them and the outer rods. After he entered inside, the door closed, touching neither the inner nor the outer rods.

He kept transmitting radio back to his space ship. Rill said, "As expected, your signal is weaker, but as promised by the humans, they are retransmitting. Their signal comes to us as strongly as yours did when you were outside; it comes from an antenna at one end of the vehicle."

Then came a surprise. A bladder that Gell had paid no attention to got smaller and smaller. A needle on what looked like a dial changed position. Its movement slowed and stopped. A light, which had been 'red' turned 'green.' The second door opened.

Four humanoid and two many-legged robots stood before him. They all had their feet on a flat, solid surface. It was fuzzier than any he had seen before. That was the 'floor.' The sharp surfaces were the 'walls' and 'ceiling'. The room had no rods in it. Gell decided that the 'floor' had a surface that connected mechanically to the bottom of his feet. With the resolution of his human eyes, it looked fuzzy.

Carefully and slowly, he rotated along his long axis so his feet pointed the same way as the others and pushed himself down. He found that when his head and eyes were in their default positions, he could see the others fine. He stuck to the floor. When he lifted one foot, it disconnected with a little force.

He also picked up faint signals in wires next to images of what were called 'ears' by the humans. Ears made sense. He had them in his

organic body. You could not determine a source's direction very well, although you could vaguely. His inorganic body in his space ship listened to low frequency radio instead of sound. When he wanted to be more precise with radio, he not only had to integrate the signal over time, he had to convert the results to sight, since vision was much more detailed.

Presumably, he was actually hearing sound in an atmosphere!

One of the robots pointed to a display. It came on with pictures of the six of them and of him, in a space to the right. The background was blank. Rill said over the radio, "I am receiving a radio image of the display as well as what you are sending. The two are identical."

"I can see the display but I am not receiving any radio from them in here," said Gell.

The pictures were not live; they were frozen. However Gell could see the similarities with the actual robots in front of him. They were in corresponding positions. Then words appeared beneath each image of a robot, except his. The third robot from the left, an actual robot, not an image, pointed to the robot farthest on the left and said, "Djem Galt Dorodden." That robot moved his head forward and said "Djem." The farthest left robot in the image moved, too. Then the third robot from the left, the same robot as before, pointed to the next robot and said "Telren Dowwen." The second robot, who did not look human at all, dipped his head and said "Telren." The robot then pointed to himself, who looked human, and said "Aglar Ivden." He waited a second, then nodded his head and said "Aglar." Then he went on to the next three, "Leestel Kemmel," "Tuppak Nassik," who had many legs, and finally "Djaeds Summervil."

Then Aglar Ivden pointed at Gell but did not say anything. Gell had already figured out the intent — Aglar was naming each person. He spoke the multi-syllable name of each. Since the names were long, none had central status, or at least, they would not have it in Gell's culture. When the robots themselves spoke, they dropped the last syllables. Aglar Ivden did not know Gell's name. Gell said "Gell." Aglar cocked his head and Gell moved his head forward just like previous robots and again said "Gell." On the display, the word 'Gell' appeared below his image.

Rill spoke to Gell via radio. "Those words are very likely names. You did right to name yourself." Gell had to agree. Rill continued. "Look in the dictionary. Interestingly, there does not seem to be any connection between status and length of name. Usually, the name is in several parts. That means it has to be in multiple syllables. One part refers to the individual and the other to his city, or rather, to his genetic lineage."

Gell thought about it. "If they refer to me, and me only, as Gell," he said, "then we will know the words are personal. On the other hand, if they also refer to you as Gell, then the words are not personal. We shall see."

Not only did the multi-legged robots look different from the two-legged robots, but they all looked different from each other. The multi-legged robot called 'Tuppak Nassik' somehow looked older than the one called 'Telren Dowwen.' Also, the 'Tuppak Nassik' robot sat on four legs and held up his front two as if they were arms; but 'Telren Dowwen' sat comfortably on all six.

The two-legged robot called 'Djaeds Summervil' had more symmetrical and angular proportions than 'Djem Galt Dorodden,' who was also the only one to have five syllables in his name. Both of them looked different from 'Leestel Kemmel'. The robot who looked most like Gell was called 'Aglar Ivden' and he did not look exactly like Gell. By thinking about the human's dictionary, Gell hoped to discover what the humans thought important. He already had the data in the human's dictionary. That was not enough. He would have to consider it. 'That is the purpose of this trip to the inner planet,' thought Gell, 'learning context and cues.'

At that point the display changed dramatically and all the humans turned to look at it.

"Are you catching this?" asked Gell of Rill. "Yes, the radio transmissions are coming both from you and from the humans' space ship. You are sending more than the space ship, which is just sending the image on the display. Oh, wait a moment, on yet another frequency, the human space ship is rebroadcasting what you transmit. We have recorded it all; I just had not noticed." "That is fine," said Gell. "You should probably focus on what I am transmitting, since that is what I perceive."

On the display, the image showed a dotted line which came from the position of the two space ships. All the planets were in the right locations for the present. The line intersected the orbit of the inner planet but there was nothing there. The planets started moving visibly. In other words, in the display time went by more quickly than normal. A bigger spot moved along the dotted line from the original position of the two space ships. After the spot passed, the dots on the line changed to dashes. When the spot reached the orbit of the inner planet, it had moved to the position of the spot.

The planet was indicated by a filled-in circle that was a bit bigger than the spot. Clearly, the planet and the spot were not to scale. Gell was confident the spot stood for the human space ship.

Then the display changed again, and showed the outside of the human space ship. The four rather small magnetospheric plasma devices

blinked, or the images blinked and showed with dots where they would be located if the resolution were high enough. Each device was equidistant from its neighbors, so the four made a circle around the ship, all on a plane that appeared to go through its center.

Gell thought, 'The humans will show ionized gas coming from the magnetospheric plasma injectors with dots and a magnetic build up with curved lines; the dots and lines will be their conventions.' And they were. "Hah!" said Gell to Rill. "I predicted the humans conventions. The dots stand for ionized atoms or molecules of gas and the lines for the magnetic field they are building."

"Yes," said Rill, "I pick up both in reality. You are on a space ship that is getting ready to move. It has started moving, but not much. Only sensitive detectors can tell. However, it is beginning.

"Based on the size of that disk which we think is the solar collector and the orbit shown earlier, your acceleration will be about the same as ours when we make interplanetary journeys. It will be less than the force produced by the gravity on the inner planet. But you will stick to your 'floor'; it will be an introduction to the solid/near-vacuum interface in a gravitational field that they have. Better you than me."

"I wish you hadn't said that last," said Gell.

"Well, it's true," said Rill. "You are more of an xenologist than I am. I have to say, friendly as they are, these humans are very strange. You have a better chance than anyone else of understanding them and coming back."

"I hope so," said Gell. He was not sure whether to be worried or comforted by the conversation. The humans were friendly. And they were trying to understand. Whether the two species could get along: that was another matter. He did not know yet.

Over a remarkably brief time, the vehicle's acceleration increased. It then held stable. Gell did not think much of the acceleration. It was weak. Nonetheless, the space ship fell towards the sun. Its magnetic field, along with the star's wind pushing against it at an angle slowed them sufficiently to intercept Ulterius' orbit. Since the solar power collector was always aimed at the the sun and bathed by sunlight, acceleration was continuous. The vehicle would get them to the inner planet about as quickly as any but an interstellar space ship pushed by particle accelerators.

A ball, a glob of some liquid, and a hollow piece of pipe cluttered to the floor early on. They had been loose and hidden, floating in unknown places, unwafted by the moving air. The liquid glob had not evaporated as water would have. Nothing else had been lost or left behind. Or thought Gell, 'nothing else visible with these low resolution eyes.' It was not until later that he remembered that his original organic body

had the same resolution eyes. He decided he had been in an inorganic body with good sensors for too long.

Aglar Ivden seemed to be the leader of this group. That is what Gell decided. The 'man', as Gell remembered, pointed at the display. It promptly showed an image of the side of a generic humanoid robot, not unlike any of them. Then it focused on the side of the robot's head. Gell could see that its mouth was open wide. Next, the display showed the skin around the mouth and throat curling away. Teeth, tongue, a complex around the place where the mouth cavity ended, Gell could see all that. He decided that the humans were giving him an anatomy lesson, maybe not of a robot but a human. That was fine, but he did not know yet or why.

Then speakers associated with the display said "ah." Gell's aural sensors picked up signals. A letter appeared on the display below the face. Aglar repeated the "ah" sound. 'Sounds in my ears,' thought Gell; 'that is what I have to start thinking. Sounds from speakers and from Aglar Ivden.'

Following that, the display divided itself into two parts. The top continued to show the robot's head and the letter, albeit somewhat smaller. The bottom part first showed a recorded movie of his own self pulling in his extended visual sensors as he entered the hole in the back of the humanoid robot. In the movie, the connection points were sharply visible. Then the display showed a sketch of him in the hole itself. The robot's wires touched his connections.

In the display, the connections and wires to his 'ears' blinked. The speakers on the display said "ah" again and Gell heard it. The sketch then showed signals, obviously much slowed down, coming along the wires to the connections. Those signals, when speeded up, were exactly the same as those he recorded when he heard the "ah" sound.

Gell contacted Rill by radio. "Are you getting this?" he asked. "Yes." said Rill, "both from you, and from the ship, which is sending the signals for the display and the signals from you." "Good," said Gell. "Please transmit a 'yes' as we did before."

Immediately, which is to say as soon as Rill sent the 'yes,' the lower part of the display blinked another set of connections. Gell had never studied these. It showed signals moving slowly and going out from Gell's connections and into the humanoid robot's wires. The signals were the same as those coming in. Gell doubted that was the situation in any organic being but it made his life simpler. He figured that signals on these connections controlled his atmospheric voice. He sent signals through his connections like those he had heard, that is to say speeded up signals, and heard himself say "ah." He realized his mouth, tongue, and other internal parts had moved.

The top part of the display promptly moved its head up and down, made a sound, and printed letters to indicate 'yes'. In Gell's receiver, Rill said, "We got that 'yes' both from your transmissions and from the ship."

The top part of the display expanded to fill the whole screen, showing the dissected side of the head. Again, the speaker on the screen said "ah," the tongue and mouth holding a shape. A letter appeared below the mouth, and Gell repeated the sound. Then the tongue and mouth changed shape, the speaker said "eh" and a different letter appeared below the mouth. Gell repeated the new sound. The display and its speaker, along with Gell, went through more than a gross of sounds, each with its own letter. Gell had not realized there could be that many. By simply repeating the signals that had come in, he could command his robot voice to say them.

Finally, the display showed three columns. On the left were the symbols for every sound. In the middle were symbols that looked almost the same, but not quite. Often, they looked simpler. Many of the letters were the same as those shown earlier for names. Several of the same middle symbols sat beside slightly different first column symbols. Even with duplication, there were empty spaces to the right of the first column symbols. The third column held only one of each of the second column symbols, each beside a specific pair of first and second column symbols. The number of third column symbols was fewer than a quarter of the number in the first row.

Gell thought about the display for a moment, then he said to Rill, "My belief is that the first column consists of symbols for sounds that can be said by human speakers, or at least, have been said.

"The second column shows the symbols that humans use regularly. The duplicates indicate that meaning can be extracted from speech even when the sounds are different. The third column shows the preferred sound of each symbol. The names are made up of symbols, perhaps I should call them letters, from the third column. The humans do not use everyday all the sounds they can make. If their set of symbols for sounds, if their 'alphabet,' is an indicator, they do not use all of them for written words. The letters we saw earlier for their 'yes' sound like a what I heard spoken for each of the symbols that make up 'yes.' "

He paused for a moment. "I can now say in this atmosphere any of the words in the dictionary. It is not as convenient or as fast as radio, but the mode is like the way we communicate at home among organic bodies."

He did not know, but his humanoid body looked thoughtful. "I not only can hear and say the words in this atmosphere, which I presume is similar to their home atmosphere, I even understand a bit of their grammar. It is closer to some of our mathematics than it is to our

language. What we think as the subject, object, indirect object, and so on act as arguments to their verb, which always comes last."

He sped through the humans' dictionary, which made much more sense now than it had before, even though he had not learned any new words. "The 'language' — that is the word they use — the language the humans prefer was invented," he told Rill. "A group which included mathematicians developed it.

"Before that," Gell said, "the humans had a huge number of what they call 'natural languages.' The sounds for one language or another could be displayed visually by a subset of the symbols in the first column. When taken all together, those symbols stand for every sound the humans use in language. Those symbols were invented because not all languages have their own phonetic alphabet or even have an alphabet!

"The humans are not like us, who have had one language since the beginning of civilization. Maybe those hypotheses are right, that before civilization we had many languages, too, but that political unification meant linguistic unification as well."

Gell studied the dictionary longer. "On a different topic, but much more important, it looks as if these humans have already spread interstellar a little ways. We cannot be sure of destroying them; we are going to have to cooperate with them. This one language, which is very nice, is spoken on two planets, Melior and Farhaven. Many languages come from a third planet that they call 'Earth.'"

"Presumably, that planet provided their original solid/gas-in-a-near-vacuum interface," said Rill. "Yes," said Gell. "A few call the planet 'Terra,' which means 'earth' in another language. They are definitely into sticking to a solid. They are not swimmers at all."

"They are very alien," said Rill. "That is for sure," said Gell.

"Meanwhile, it looks like the humans have been settled on three planets for a long time, and this one we are going to, which is new, is the fourth."

"We only have the one home planet and this one," said Rill.

"At least, the humans have been friendly," said Gell. "Our planets don't compete. They are too different. Few, if any, will want to live in the other environment, and they certainly cannot live in their regular bodies. As for the material in space that we both can reach, I hope we can divide it."

Gell experimented with the humans' language. "We travel to the planet," he said. The robotic humans, even the multi-legged ones, all nodded and made a vocal sound that corresponded to the 'yes' he knew.

Then they all looked at the display and Aglar pointed to it. The dissected head, which Gell realized now looked like him, repeated the words he had spoken, "We travel to the planet." The mouth, tongue,

and lips all moved as his had moved. Below the mouth, two lines appeared, moving from left to right.

The top line had symbols that showed the particular sounds he made. Its symbols were from the left-most column of the earlier display. The bottom line had symbols from the right-most column. Gell decided he was right: those relatively few symbols appeared in the humans' everyday alphabet.

Gell rediscovered the convenience of speech in an atmosphere. It was not as fast as radio, but that took inorganic technology. Speaking did not. It did not require visual seeing. A speaker might be a different room or otherwise hidden. The humans could only see in front, so speaking was more useful to them than to any creature that could see all around.

Just as poor light detectors turned into excellent eyes, lousy acoustic sensors could, over a huge stretch of time, become sensitive ears. That took care of the receiver. Neither his people nor the humans nor either's ancestors had ever produced light. For them, light would be a poor signalling mechanism. But both had evolved sound generators. Gell thought for a moment. Many creatures produced sound. Many had a good sized vocabulary, too. But humans were only the second species he knew about that had invented grammar, which enabled them to distinguish 'the swimmer flew over the hill' from 'the hill flew over the swimmer.' With grammar, an entity who heard could link many words without becoming confused.

The human's dictionary now contained more than pointed to or pantomimed images. The humans had added to the original and sent him the information by radio. Gell finally begin to understand the new material. He came across the sentence, 'Man bites dog.' He knew what the word 'man' signified, a male human, or, in the old days, any human. He knew that a 'dog' was a carnivore with whom humans allied. 'Bite' meant 'chomping teeth.' More often than omnivores, carnivores chomped their teeth on large, mobile, living beings. In general, dogs had teeth more suitable for biting and killing another animal than humans. So he understood the sentence and, because of its grammar, he knew the phrasing was unusual. The usual phrasing would be, 'Dog bites man.' Every speaker would know what he as speaker intended, but without grammar, a recipient might not.

Molecular transport would provide another communication mechanism. Like sights and sounds, plants and animals signaled though smell. So molecular receptors were useful. He bet humans could smell. The humanoid robot body that he wore was a human duplicate. He was sure it had the right sort of sensors. He would find out. He had not investigated all his incoming signals yet. It would not be hard to produce

smells either. Gell knew that the waste products from organic beings contained volatiles with a huge amount of information in them.

But smells moved through an atmosphere slower than sound. They were not good for warning. Similarly, they might never reach a colleague moving quickly through the air. They were not good for distant cooperation.

Warning and cooperation, ultimately, understanding — all contributed to making sound a better communications medium than light or molecules.

Except that with technology, with a type of light, with radio, you could communicate over longer distances more quickly than you could with sound. Moreover, you did not require anything in between the transmitter and the receiver. The signal crossed a vacuum. You could send more information at the same time, too. For a technological civilization, radio was better.

Gell passed on those thoughts to Rill and said, "I am trying to understand where these humanoid robots came from, the organic humans they are based on. That is a good reason for sound in an atmosphere."

He paused for a moment. "I suppose they are trying to find out the same about my sources."

He spoke more. "Perhaps we should produce a dictionary for them. They will find out eventually. All they have to do is send a space ship to our star. They do not have to announce themselves. Probably, they won't be discovered."

Neither had thought of a thick sensor net built by assemblers.

Rill broke in, "I agree, the humans won't be discovered. They do not even have to go to the Sun. They can stop themselves at the Bright Wanderer." That was the traditional name for the system's other stellar component. "We have not had any ship close to it for a long time, no need."

"That's true," said Gell. "The humans could lay off in the Oort Cloud, have assemblers build large, sensitive receivers, and listen to our radio. Most signals are not encrypted since it does not matter whether a different faction picks them up. Those signals will tell them the most even though to us they are the least interesting. They could use assemblers to build devices that would destroy us. We have got to cooperate. The universe is dangerous."

"We could retaliate," said Rill.

"Yes, we could," said Gell. "Then we would both become irrelevant. I am sure a third party would prefer that. Only through cooperation can we be successful."

Gell stopped speaking for a moment, then became practical. "We should make a dictionary for the humans and, once they understand, be

prepared to give them encyclopedias, literature, and the like. At least the organic humans cannot live on our type of planet."

"And vice-versa," said Rill, "so if it occurs, our competition will be in the depths of space.

"I suppose that is good enough reason for a fight," Rill went on. "It would be enough reason for a few of us. Some of the humans may think like we do on this, even if they look differently. And nowadays, with fast assemblers, which the humans have — they have an entry in their dictionary, they call them von Neumann machines or assemblers; . . . there is a difference: von Neumann machines are assemblers plus recorders. With either, you don't have to be central to cause damage. This is troublesome."

He thought for a moment. "You are right about third parties, other aliens. We should be concerned about aliens with a level of technology that is equal to ours and with those more advanced. Probabilistically speaking, we should meet the more advanced. We have not seen any obviously artificial constructs. Maybe they have killed themselves off. Or maybe they are doing something different."

"Maybe they focus on matter that does not respond to electric fields," said Gell.

"That is what I mean by 'something different,'" said Rill. "Besides, our kind of matter responds to more than electric fields."

"That is true," said Gell, "but every big material object always feels an electromagnetic field. At least, every material object that we know. These humans are made of matter just as we. They use it like we do. We can see them. In one sense, they are very alien, living on a solid to a gas-in-near-vacuum interface; in another sense, they are very like us. Please produce a dictionary for the humans."

Rill said, "A small portion of the humans could act against us without the rest knowing. What could we do against that?"

Gell did not speak for a moment, then he asked rhetorically, "How did the humans discover us? Von Neumann machines, as the humans call them, could build many sensors. That would be enough. And it would not cost anything except a little time. Maybe that is what the humans built. If we did the same, no interstellar space ship could approach without our knowing it. Then no one could destroy us. They could hurt us, but not destroy us. "We can protect ourselves against destruction," said Gell. "We cannot prevent others from learning about us by listening to radio signals. At another star they are fainter than in our Oort Cloud, but assemblers could build receivers that are sensitive enough. And if some one else got into an empty system first, and did not like us, we wouldn't be able to settle on our type of planet without their cooperation. We had better give them a dictionary. It will not

tell them anything they could not learn otherwise. And it will show we are friendly."

Then he shifted topics. "I have been speaking of a 'gas in a near vacuum.' That makes sense from our perspective. But the humans probably do not think of it as a near vacuum. They are more likely to think of their common air pressure as normal. I bet they think of us, or rather our organic equivalents, as living in a high pressure gas."

"Yes," said Rill. "They are very strange. We will work on the dictionary."

Gell did not reply.

Gell found he understood the humans better after finding he stuck to the floor because of acceleration and lived in a body with eyes that only looked ahead.

The human sensorium was not impossible. In fact, it was quite well adapted to their environment. Moreover, they could swim! Usually, they remained on the interface between water, a high density liquid they could not breath, and air they could breath.

The density of water was about the same as his air. No wonder he could swim in it. That is why the humans called his people 'swimmers.'

The humans could swim in water; they referred to it as 'swimming under water.' With technological assistance, the humans could stay under water for a considerable time. They wore artificial fins on their feet. However, most of the time, they lived in a low density atmosphere, stuck to a solid.

In not much more than a quarter of the day of his original planet, Gell and Rill were out of convenient conversational range. Rill's receiver picked up everything Gell's humanoid body signaled Gell. Also, Gell sent reports. But it felt different. He was very alone.

The humans, considerately, picked up his transmissions in their space ship and retransmitted them more powerfully. Gell's transmissions were encrypted and he had not the murkiest idea whether the humans could understand them.

Rill sent part of the dictionary intended for humans. It was unencrypted and took longer to prepare than the human dictionary. Gell separated his hands, moved them apart, and then repeated the process with a smaller separation. He did this several times. The humans all watched. Finally, Telren said, "I think he is trying to say that he is sending us only a part."

"Ah," said Aglar, who then showed Gell the human dictionary entry for 'part.' It pictured a dozen items, including a moving one in which a sphere was repeatedly built up out of slices. Each slice was called a 'part.' When the whole sphere came together, it was called, like the other complete items, a 'whole'.

Gell nodded; he knew about nods, now. He said, "Dictionary for humans is part. It will be whole." Aglar nodded, indicating a yes. All the humans began looking at it closely.

Tuppak Nassik went to the entry on Xi Bootis, found it, looked at the numbers for the sizes of the major components, they matched estimates, he nodded; he looked at the diagram for the major component and found it had a Jovian planet. Indeed, it had several; all but one were in orbits much colder than the Ulterius Jovian. One received about the same amount of radiation from its central star, not quite a seventh more. Gell pointed at that planet and then pointed at himself. Tuppak decided that that Jovian was Gell's home planet. From a distance and not knowing of Gell and his people, the planet had been called Muzhda. No one knew the source of word. It would continue to do as a name.

The dictionary contained more line drawings. Gell recognized several as coming from more complex pictures he had seen. They had been simplified to make the dictionary. The first on-planet image that Tuppak looked at was of the central city, a disk floating serenely in the middle of its south tropical wind belt.

Tuppak looked at the disk then at the scale. His eyes grew larger. "That is huge," he said to Gell, "grosses of grosses of meters wide, a dozen great-grosses. Did you live near that?" Gell nodded. He had never lived near the central city, but now was not the time to explain ranking, not that he could as yet.

"Looks to me like a pancake," Tuppak said. Gell had to find the entry in the human dictionary for pancake. The entry had a picture. The central city did look like a pancake. But Gell did not like the other connotations. For one, humans ate pancakes. There was a picture of humans eating pancakes. Organic humans gathered energy by eating, as did his organic people. Except for the details like floating, pressures, and the like, they were similar.

Tuppak ignored all. He said, "The ecology makes sense." Gell was not sure what 'ecology' meant but the phrase 'makes sense' was a kind of 'yes.' Then Gell found that an ecology included many plants and animals. He was able to nod, but Tuppak had turned away and looked at the other humans.

"Probably, these huge pancakes grew out of original conglomerations of cells, like Earthly stromatolites, but grew bigger than any on Earth because the centers of their climatic bands or wind belts are calm. After a few eons in which successful changes survived, they grew complex and people like Gell evolved." Tuppak was excited.

Gell did not like cities being referred to as 'pancakes.' The word 'disk' was not much better since it implied death. Cities were alive. He thought what would be good for the humans, then nodded and smiled to himself.

Aglar spoke by radio to the other humanoid robots. He did not include Gell. "*Tree tortoises*, that is what Gell is now proposing we call them." He sounded disgusted. "They do not look like tortoises and they don't live on trees. The name is misleading."

The other humans had heard Gell make the proposal, but this was a side comment.

The AI explained, "Gell proposes they call themselves tortoises because they swim through a thick fluid — where they evolved, much of the atmosphere consists of what we normally think of as gases, but under such pressure, the gases have about the density of water. Because they swim, I suspect he is thinking they see themselves as similar to sea turtles.

"Trees are what he plans to call the huge pancakes of solid stuff on which they live. I suspect that before they developed technology, these creatures rooted around and hid in them. Perhaps he thinks that those islands fill the same ecological niche as terrestrial trees. I suppose if he thinks of himself as a flying insect that hides in a tree's bark, that might be true.

"In fact, tree tortoises look more like fish with hands than anything else humans know. A better name would have been 'hand-fish'. More precisely, the aliens look like sea mammals with split front flippers that they use as hands, and horizontal back flippers that they swim with, like Earthly whales. The back flippers or fins are larger than the front ones, but each has four lobes like the others."

"I like calling them 'tree tortoises,'" said Tuppak. "Those big disks are trees, huge trees. They have grown and grown and grown. They don't look like Earthly trees, but then we should not expect them to. The critical issue is that they are alive and they are not animals. 'Tree' is a good word.

"As for 'hand-fish': that may be what these aliens look like, but the word is going to be for humans. We are not trying to replicate what they call themselves."

Tuppak was stern. "In general, humans prefer tortoises to fish. To most human people, tortoises are slow and harmless. Gell is smarter than an average human, at least analytically. Also, he is good at understanding others not of his species. I don't know the capabilities of others in his species. Regardless of that, we are more likely to have humans willing to cooperate with these creatures if we call them 'tree tortoises' than if we call them 'hand-fish'.

"Aglar came up with a politically useful notion, that because Gell originally swam, he saw himself as a sea turtle. That is a good explanation. And the phrase 'tree tortoise' sets people to think more of cooperation than conflict."

Shortly thereafter, Tuppak told Gell, "Let us go to your bedroom."

That meant Gell had to learn to walk. That turned out to be easy. He sent a signal through yet another connection and that caused both legs to move alternately. Gell decided that the signal went from him to a human computer that told the legs what to do.

He went down a spiral staircase. Tuppak said, "Please look at the entry for 'standard interplanetary space ship' in our dictionary." Tuppak had the ship transmit the entry to both of them. It showed the design: the large public room was at the top. The bottom level held the main garden where organic humans' carbon dioxide and other wastes were recycled. It had carbon dioxide exhaling animals, too. Organic humans often came to that garden and there were seats and tables for them. However, there were no organic humans on the ship. So the garden contained no people. Tuppak could not figure out how to explain the complications of the design, so he didn't

The top also included a dining room for organic humans. Since Tuppak, Gell, and the rest were all robots, none needed human food. However, they could pretend to be organic and eat food. Since eating was so important to organic humans, and since Gell was trying to understand, everyone would eat. Tuppak did not try to explain food to Gell either.

Gell asked, "What is sleep to humans?" Tuppak nodded and quickly looked for 'sleep' in the aliens' dictionary. He found it by searching for 'regular unconsciousness.'

It turned out that the tree tortoises were never fully unconscious, or none of the early tree tortoises. They were more like some Earthly sea creatures. While a half the brain slept, the other half stayed awake, although that was not necessary for tree tortoises that slept in houses; they did not have to watch for predators and beds kept them from drifting away. Tuppak wondered how 'awake' was the half that in primitive times kept watch. Certainly it was not in deep sleep, but protective houses and beds suggested less than full alertness.

"For humans," Tuppak said, "sleep is unconsciousness. No two sides of the brain; no awake side." He decided it was too complicated to speak of states of sleep or the two sides of a human brain or that any human could wake when they heard a strange sound. "Sleep restores," he said. Gell nodded.

Then it occurred to Tuppak that if Gell were following his Jovian's time, he would be resting two or three times during a human day. He asked Gell, "When do you sleep?"

"When — I not know your word," said Gell. "Now I know. We have the same notion. Organic tree tortoises sleep five times in two human days. Inorganic robots, like me, sleep at many different times: once in two human days; five times in two human days.

"Perhaps the word you seek is 'occasionally,' as in 'a robot sleeps occasionally,'" said Tuppak.

Gell looked in his copy of the humans' dictionary. He nodded his head, 'yes;' then he shook it, 'no.' "Not occasionally," he said, "one time every two humans days. Different times: once in two human days; five times in two human days."

"'Not regularly,' that is the phrase," said Tuppak, "'a robot does not sleep regularly.'" Gell looked in his copy of the human dictionary, looked at the explanation of 'regular,' negated it, and nodded 'yes'.

Then he spoke again. "Sleep restores inorganic robots and organic tree tortoises," Gell said. This time, Tuppak nodded.

Just as organic humans needed sleep, inorganic robots like him valued it as a way to settle thoughts. Computations could and did carry on; the thoughts of intelligent beings were complex. Like the tree tortoise robots — Tuppak liked the term 'tree tortoise' more and more — human robots were not as dependent on sleep as organic humans. If necessary, human robots could keep a part of their minds fully conscious.

Tuppak decided that the instances of sleep provided fairly strong evidence that every complex thinking device required it. After all the tree tortoises must have developed differently than humans; the software of their minds could not be the same. So if the organic and inorganic parts of both species needed sleep, at least occasionally, then that requirement must belong to the nature of creatures with thought. It was not a peculiarity of humans minds developing in organic bodies and then unintentionally recreating familiar characteristics in their computers.

Before going to sleep himself, Gell investigated the humans' dictionary. He discovered the word that humans used for a human who studied other humans was 'anthropologist' and that the word for studying aliens was 'xenologist.'

Gell wondered whether he was an 'anthropo-xenologist' or a 'xeno-anthropologist.' From the humans point of view, he would be the latter, a 'xeno-anthropologist,' a stranger studying humans. But from his point of view, he would be the former, an 'anthropo-xenologist,' a studier of aliens who were human.

Regardless, 'anthropo,' as well as the other parts of the word, came from an older language that had not vanished so much as transformed over generations into a modern language. That language was not the dominant; indeed, it was spoken by a small minority; but it existed. Gell thought about his planet and his people, 'Perhaps linguists can find evidence that before we became one polity, we spoke many languages. It has been a long time, but we do not change very fast.'

Like Gell, Tuppak felt refreshed when he woke up the next morning. Whatever processing his inorganic brain did while he was 'asleep', it made a difference.

Tuppak talked to the other humans about the tree tortoises' Jovian. "The high gravity causes a steep atmospheric gradient. Although the aliens can endure much bigger pressure and temperature differences than humans, their safe range of altitudes is thin by Earthly planetary standards.

"Tree tortoises have a double-dozen base, as we know. That is because each tree tortoise has six fins and each of those divides into four parts.

"Because of our base twelve numerical system, and the tips and knuckles of human fingers, we like to think in terms of halves, thirds, and quarters, with sixths a distant fourth. Those humans who use a base ten system end up going to hundredths not tenths. They prefer halves, quarters, and tenths, in that order. Tree tortoises prefer halves, quarters, and sixths.

"I have looked at their dictionary. None of the aliens leave their home world directly as biological entities. That is my big discovery.

"Were they to go into space as organic beings, their space ships would have to withstand enormous pressure. Space ships like that could be built, but they would weigh too much for convenient launch.

"Instead, tree tortoises ride robots. First, they rode them as telepresence passengers. However, any Jovian planet is so big that the speed-of-light delay prevents one from doing anything active except providing hints to an otherwise independent computer. So computers had to become independent, except they never became independent of tree tortoises.

"They learned to download themselves into those computers. They never did create AIs like Aglar or Adkel. At least, none are mentioned in their dictionary.

"The aliens don't use rockets either. That is another important discovery. The orbital and escape velocities for their home are too high. Instead, they accelerate a superconducting magnetic set of cables in the planet's magnetic field. That is described. The cables pull a payload which is in a pallet that collects energy. For such an accelerator to succeed, a planet needs a magnetic field much stronger than that of Earth or indeed, of most Jovians. That limits what they seek.

"We happen to have a suitable planet in this system," he said dryly.

"The superconducting magnetic set of cables must accelerate in near vacuum. To reach that vacuum, they run a ramjet in the atmosphere to build up speed, then pop it up. The superconducting cables need huge amounts of energy, far more than any rocket can carry in chemicals, even with a full conversion of chemical to kinetic energy."

The non-biological engineer in him was excited. "After inventing assemblers, as far as I can see from the time line in the aliens' dictionary, one their first big projects was to build enough microwave transmitters

to feed enough energy to a relatively light object with cables attached that accelerated far enough, half way around the planet, to build up enough speed for orbit.

"That is how they got off the planet. We are so different. We used and still use rockets. Of course, none of our planets have a strong enough magnetic field. Because of their composition, none could."

Years before, he had invented human organic rebirth. "Also, based on what is not in their dictionary — that is absence of evidence, not evidence of absence, although I am presuming their dictionary is becoming complete — the aliens have not implemented organic rebirth. They may have it yet. I have not seen references to it. It may be a hope."

Tuppak paused. 'If it is a hope,' he thought to himself, 'everyone in this system is either courageous or likes an inorganic substrate.' He continued speaking out loud, "Whatever we do that is more or less peaceful, the alien is going to seed our system's Jovian planet with his own life forms, all microscopic. As far as we can see, the planet has been dead, so their addition does not matter. Without accelerated growing, which I have not seen mentioned either, nothing will grow quickly. I doubt that even if they could be reborn into organic bodies, they would find anything big enough in less than a gross of terrestrial years and that might be too short a time."

He shifted topics, which he indicated by shifting himself and by words. "As for trees, those huge living pancakes on the Jovian by Xi Bootis: when they straddle different wind zones, an edge may flap or come off. They often have a dozen to one thickness to width ratio. That is another way of saying that they are thin and weak. They can't be big and be in turbulence at the same time.

"Trees float in a single wind zone or belt at a specific pressure. Now that I think about it, they must be near the top of an atmospheric feature that would be considered a high closer to the interior of the planet. The air around Jovian trees slowly goes down though they themselves float. In the old days, such a band on Jupiter would have been called a belt. It would have been darker than a zone. On Jupiter, zones were lighter-hued and the air rose."

"That is not useful language," said Telren. "Not for the rest of us. We think of every band as a zone, whether the air in it is rising or falling."

"That's fine," said Tuppak. "I am just telling you the original jargon. Belts and zones looked different from a distance. Color was the criterion. Initially, no one knew whether an atmosphere that produced zones or belts was rising or falling. All that knowledge came later — a long time ago for us, but considerably after the invention of the telescope.

"In any event, at the altitude where trees float, horizontal air movement tends to push them towards the center of a band. That is why so few are found in turbulence near edges."

The trip seemed to take no time at all. Gell became a great deal better at speaking to the humans. In addition, all the robots pretended they were organic humans and ate every day. The group included Tuppak and Telren, who both had many legs.

Gell was fascinated when he discovered he could pour water from a pitcher into a glass. It was not that he did not understand the principle: at the water's temperature, which was suitable for his drinking, the atmospheric pressure was high enough to prevent it boiling but low enough so it stayed separate from the air, as liquid water. He understood; he had never thought of it before.

Since they ate, they had to excrete. The robots did not gain their energy from human food, so excreta was not as changed as in organic humans. But it was masticated and mixed. Aglar said that it recycled fine.

Mostly, the robots ate vegetables, such as carrots and peas. Once they ate pork. They did not exhale carbon dioxide and Gell imagined that to replace exhalations from the pig, hidden robots burned biomass.

Gell discovered that his humanoid robot body provided him with tastes and smells, too. He discovered the human taste of salt by eating peas with more and more salt on them. As expected, if only because his mind interpreted the signals similarly, its taste was similar to the taste of salt as detected by his original organic body.

To discover sweetness, he added more and more sugar to a drink the humans called 'coffee'. The humans' sugar was a different substance than that which provided a sweet taste to his original organic body but did the same for humans as the equivalent did for tree tortoises. Someone somewhere had correlated the internal actions of the two kinds of body and the taste corresponded.

Gell was impressed. He did not understand yet that humans depended on non-sentient, but smart, computers to corrolate human knowledge with his dictionary and then uploaded the corrolation into his robot body.

In another experiment, Gell poured more and more vinegar onto a slice of tomato. In both his original environment and among humans, some foods were hard, others soft, some smooth, others not. They had texture as well as taste and smell.

Aglar said that 'tomatoes' were grown but 'coffee' not. It was made by an atomic assembler, a replicator, as was 'sugar'. By that time, Gell understood both the words for 'growing' and for a von Neumann assembler. Mostly, they did not use an inorganic assembler, they grew food — to Gell, that made sense, as his organic people always grew

food. However, for some substances, humans used an inorganic device to assemble what they injested. They behaved differently on a planet and on a spaceship, too. It all was odd, but humans were.

Gell could not understand everything, but he comprehended enough. Telren helped him with human eating by describing what he tasted. He used a wide variety of words and metaphors. Tuppak surprised Gell by saying that he had not paid much attention to food before and that often Telren's metaphors were new. Then Gell remembered that when he was in organic form, he had not paid much attention to food either. He knew humans were just as different from each other as tree tortoises; Tuppak and Telren provided yet more evidence.

Tuppak talked to Gell about numbers. "Do you have an old symbol for two dozen?" he asked.

"Yes," said Gell. "It is the reverse of one. Only schools use it frequently. The glyph is both obsolete and very old. Schools teach young tree tortoises to count on their lobes. That is why the glyphs for five through eight, from the right fin, grow bigger but the glyphs from one dozen five through one dozen eight grow smaller: they are mirror images of one another."

He drew a seven and one dozen six as examples. The seven consisted of a horizontal line with a short downward line to its left and after a longer space than usual, three vertical lines, all below the horizontal line. One dozen six looked the same except that the short downward line was at the right end of the horizontal line and the longer space was to its left before the three vertical lines.

Gell continued speaking. "The glyph for a double-dozen is the mirror of the glyph for one." He drew them both, the one with a twirl on the left, the double-dozen with a twirl on the right.

"A problem teachers have met since the beginning and still meet is when some children think that a dozen and a half is half a double dozen. That is because fins on the right go from one to a dozen and fins on the left go from a dozen plus one to a double dozen. They figure half must be half way between a dozen and a dozen plus one. The number of lobes on each side are the same."

Tuppak felt confirmed. Gell smiled. "Our teachers explain that with integers there are no fractions. To divide a double dozen into two parts means each part has a dozen. They see that on a calender with days and no fractions. Teachers give an example of four; even small tree tortoises can visualize four.

"Then teachers talk about half being a fraction. They must mention a half, a quarter, a sixth since adults speak the terms frequently. Fortunately, young tree tortoises will wait until they are old enough to learn the arithmetic of fractions. It is hard to teach fractions.

"After the young become old enough to understand, teachers say, 'When anyone takes a number that looks like an integer, that number may include its fractions; or it may not. Often, it does not. Thus, a double-dozen seldom includes the fractions between a double-dozen and a double-dozen plus one. That is very important.

"'Every number below a top number including one and the number just below the top includes fractions that lead up to the next higher number. When you find halves and quarters and sixths, you must include them. You must consider all the fractions below one. So a dozen and no fractions is half a double dozen and no fractions.'"

When they came closer to the rocky planet, Aglar said to Gell, "On the station circling Ulterius, you will meet my brother, Adkel Ivden. He runs the station and the terraforming. He will also be a humanoid robot, very like me."

From the outside, Adkel's space station looked like an old-fashioned, spinning wheel. Indeed, it was an old design. For centuries, no one had seen any reason to improve it.

Adkel's robot body was remotely operated, but no one tried to tell Gell that. It was irrelevant and none knew any sure way to explain. Instead of appearing exactly the same as Aglar, Adkel had a von Neumann assembler make a robot that looked nearly the same, but be sufficiently different to be distinguished.

Like Aglar, whose processors were in his body, Adkel's eyes were dark, as were the threads on his skull that indicated dark hair. He was tall and somewhat thin. The robots for Aglar and Adkel looked like brothers.

Adkel showed Gell part of the space station. It was big. On the main level, the acceleration produced by the spin was exactly the same as the planet below. "Organic muscles take time to adapt," said Adkel. "As robots, you and I adapt immediately."

He went on. "Right now, the space station looks empty. That is because nobody is walking through the corridors or eating in its dining halls. Even after organic humans come alive, most will stay on the planet below. Eventually, its organic human population will grow and more will come here. That is what we are waiting for. In the mean time, we shut parts."

Gell did not care about the space station, so Adkel had no trouble keeping him away from the fast growth tanks. He and the other human people intended to give Gell information that none of the tree tortoises seemed to have, but not yet.

Adkel did not love humans quite as much as Aglar, even though one was a duplicate of the other. As they grew apart, they emphasized different characters. But Adkel was faithful to humans and temperate. He did not want to disclose technologies that humans had exclusively.

Nonetheless, he and the other humans all expected the tree tortoises to invent them soon. If the tree tortoises on their own did not invent them quickly, the humans planned to help. They, those that were not intrinsically generous, figured that in the long run, their assistance would create better circumstances, even if they appeared to lose in the short term.

Adkel and the other people hoped that none of the tree tortoises would be humiliated by help coming from outside, at least, none in any position to cause trouble, whether at home or in the Ulterius system. Alternatively, if they were humiliated, the humans hoped that the tree tortoises would direct their resulting anger towards yet more discovery, and that the subjects of the discovery would be peaceful. They hoped the focus would be on topics such as how to force-grow non-thinking instances of their own people, rather than on how to hurt humans.

Meanwhile, Gell paid enormous attention to the humans' planet-to-orbit-to-planet rocket. None of the humans cared what he learned. Gell's species understood the theory. Certain animals jetted themselves through his atmosphere, just as similar looking ones did in terrestrial water. It was a classic example of how eventually, over geological eons, survival meant that the design of those animals converged. 'Evolution in action,' Gell thought, 'but for anything bigger than a microbe, it is really slow.'

Then he remembered that he and animals like him all had pumps that moved air through their lungs. The exits acted as nozzles. Although the reaction was not strong, it was enough in a wild but protected spot to keep position when sleeping. Civilized tree tortoises slept in beds — they felt better when they woke — but other animals did not.

Even though he understood the theory, Gell had never considered it. No inorganic rocket would work to get off a Jovian. There was not enough energy in chemicals. An atomic rocket could not carry enough reaction mass. But from these small, inner planets . . . you could actually leave them using chemicals.

Then he realized that the payload accelerated to orbit by conducting cables was carried into near vacuum by a ramjet which solid rockets brought up to speed. When he transferred the first time from an organic to inorganic body, he had ridden such a ramjet. That was when he first became a spaceman. It was so irrelevant he had forgot. 'No,' he thought, 'it was not irrelevant, it was strange.' He had forgot both because the notion was strange and because it was not memorable.

Leestel watched Gell. She told him, "A hydrocarbon-oxygen rocket does not cause problems like an an atomic rocket. For one, it does not matter when one crashes, except in the immediate area. Crashes are

very rare, but they do occur once in a while. We do not use hydrogen for a fuel because it is easy to synthesize a higher density hydrocarbon."

"We cannot build anything like this," said Gell. "We would have to do the research and development from the beginning. Your design looks mature."

"Yes, it is," said Leestel. "We developed rockets centuries ago. We have not felt any push to improve them since then.

"A potential problem is that chemical rockets leave water vapor in the upper atmosphere where it does not rain out. But we found on Melior that there are not enough flights to matter. When the input is small, a planet does not respond by causing twice the trouble for twice the insult. The response is not linear. The planet cleans up. But when the input is big, then the planet dies. You should have an easier time on your Jovian, since it is bigger."

"We do," said Gell, "but we have been around for longer. Even before modern technology, we could do enough to effect the planet badly, or at least a zone or band. How do you prevent disaster?"

"On Earth, we didn't. There was a vast die off. I wasn't born on Earth, but everyone else remembers directly. Well . . . they were enroute to Melior when the worst happened. They could see what was going to happen and they could flee Earth. So they did. They had enough social power to flee, but not enough to change the course of the rest."

She calculated for a moment. "In base double-dozen," Leestel said, "you would need eight digits to express the number of people who once lived on Earth. Now, a sixth that number live there and you would only need seven digits. As for us Melians — in a double-dozen base, you can list our population with only five digits. We are few."

"Why did you come here?" asked Gell.

"I worked for the government," said Leestel. She meant the Melian government. "Solving problems: that is nifty. But I could see that I was not going to replace the people who came before me. Here, I will be among the first! And Djem was becoming bored. I could see that. He is an envoy from Earth, the first we ever received."

Gell knew about envoys. Different factions of his government needed to send envoys to each other.

Leestel continued. She nearly giggled. "Originally, I was assigned to spy on Djem. We did not know what to expect. I think the people on Earth were trying to get rid of him. At the same time, they wanted a smart and loyal person on Melior. He is both smart and loyal. It all fits. I like him even though he is a stick-in-the-mud and was not properly socialized when he grew up.

"Of course, we did not know you would come."

Chapter 11

Leaving the space station, Gell and the others travelled on a human rocket. It was not a simple use-once reentry vehicle which Gell's people had. It was a reusable rocket. It was not pushed by a magnetospheric plasma device, but by an engine that expelled a fast moving reaction mass in the opposite direction.

Looking at it directly, the engine gained energy by the combustion of chemicals, just like an organic being. Gell marvelled. Indirectly, of course, the chemicals merely stored energy that had been produced by nuclear fire. Every human chemical, even those 'fossil fuels' like oil and natural gas that Leestel said the humans had burned, gained their energy from nuclear reactions.

On Gell's home planet, a portion of the initial energy came from continuing gravitational contraction. His planet had not been massive enough to start nuclear fires, but it still gave considerable heat. Nonetheless, most energy came from his sun.

Humans could not get into space with their planet's weak magnetic field, so they used rockets instead. Gell thought that was very clever. Moreover, with the plans that he hoped the humans would provide, Gell's people could have their assemblers manufacture rockets and explore inner planets. Tree tortoises had sent a few probes to inner planets' surfaces, but almost no one understood what they sent back and few cared. Now, people like him, in inorganic substrates, could ride rockets. Humanoid robots were designed to operate in gravitational fields on a solid surface in a low density atmosphere (or a zero density atmosphere, for that matter). Maybe a tourist industry could exploit interests in strange environments. Such an industry would involve more people than investigation, although tourists' interests would be less focused than those of scientists.

The rocket landed horizontally on an empty 'runway' that had been prepared for the future by the terraformers. The rocket 'flew' the last part on 'wings.' They needed considerable relative motion between themselves and the atmosphere to generate suction that produced 'lift' for the vehicle. The 'wings' operated by what the humans called 'Bernoulli's principle:' a relatively faster motion of air over the top of the wings led to less pressure and therefore to more suction. Almost none of the 'lift' came from pressure below the wings.

Gell knew that nowadays the humans' engineering produced 'wings' nearly as good as they could be. He was fascinated to see that even though the general theory had come long before, time passed before the practice came anywhere near the mathematics. In part, he understood, the humans of the time lacked fast enough computing devices and could not apply the mathematics precisely. Indeed, they referred

to 'Bernoulli's principle' with emphasis on the word 'principle'. When they finally developed fast enough computing machines, they calculated with mathematics developed by later humans. Gell decided it was just like his people's engineering.

After the rocket came to a 'stop' relative to the solid surface, Gell and the others 'descended' on 'stairs' to the ground.

Even though the gravity was light, not much more than a third of his own, Gell felt strange 'walking'. He was accustomed to swimming or floating by solids, either in the atmosphere of his planet or in free fall in space.

Also, he had to stop thinking of the humans' atmosphere as being a 'near vacuum.' Although he had directed himself to avoid the thought before, he still said to himself, 'I am walking in a near vacuum.' It may have been a near vacuum for his people, but for humans, the air was normal. Organics breathed it.

You could even feel air, so long as it was moving fast. That was called 'wind.' It consisted of a relative motion between a solid such as himself and the atmosphere. Wind held up wings. Without wind, wings did not provide lift. For flying, a sufficiently fast wind was artificially generated by the vehicle's motion.

When Gell floated in an atmosphere, he hardly ever felt a difference in motion, he hardly ever felt 'wind'. He supposed that when a tree, one of his trees, got near to the edge of a band, a part might be in a different wind zone. In that case, a person could feel the motion by anchoring to the tree.

Gell looked at the humans' trees. They grew up from the solid ground into the air. On the one hand, they were shaped by gravity pulling them down with no support from the thin atmosphere; on the other hand, they were shaped by their need for light from above. Gell used the human term, 'on the one hand . . . on the other hand' because he was in a humanoid robot body. He understood the human preference for binary division; it was like his fins on the left side versus his fins on the right side. But the humans did not seem to have as easy a time converting halves into sixths. However, the difficulty could not have hurt them.

Humans did not have another hand. Thirdly, Gell thought, humans' trees responded to wind.

Gell kept looking at the humans' trees. The leaves gained energy from the sky, from the sun. Nothing on this planet gained energy from below; its interior was hot enough, but little energy radiated at a sufficiently high temperature. It was not like home, where about a third of the energy used by his trees came from below; the rest came from the sun. (Although he had the data in his mind, Gell was not aware of

plants that lived off chemical energy rather than radiant energy. The bigger lived under the Earth's oceans.)

The humans' leaves generated living material and the necessary energy. They converted light from the sun, gasses from the air, and liquid from the tree itself; 'sap,' he remembered to call it. They were not very big, not compared to the trees on his planet. Still, they were larger than he and did not move of themselves. In that sense, the two were similar. The trees on Ulterius looked more or less like their pictures. They were not like Gell's trees at all.

Gell thought to himself, 'When I speak of the *humans' leaves*, I should be careful to use the right language. Humans do not own leaves or possess them in any way except by convention. However, they are associated with them. Perhaps it would be better to think of the *leaves on the planet that is for humans*, but that phrase is long.'

Djem and Leestel demonstrated running to Gell. He emulated them. It was fun. In many ways, it was like his swimming quickly when he was a child. Except that adult humans' centers of gravity were farther from the solid ground than those of children, so they hurt themselves more when they fell. A child would never fall on Gell's home planet.

On this inner planet, Gell, too, could move over the solid surface at more than twice the speed he walked. When he ran fast, he could even feel a little wind, a 'light breeze'. On his own planet, he did not feel wind when he swam fast even though the atmosphere was so much thicker. It was very strange.

Even when running, he did not fall. His robot body stayed upright because of sensors which caused his body to make little motions that he was not aware of.

The humans led Gell away from the urban area — it covered very little area; he and everyone else walked. They went to a nearby hill. "We can look down," said Leestel. Gell thought that a little weird, since he could float and look down; then he realized that these humans, even though they were in mechanical bodies, could not do that without additional mechanical aid.

Part of the walk took them by trees and part took them by grassy meadows. Gell thought that the land-based grasses looked vaguely like his own. On investigating his memory, however, he found that grasses on his home world looked closer to terrestrial sea grasses. 'That makes sense,' he thought, 'sea grasses live within a substance with about the same density as my atmosphere.'

The land-based grasses Gell saw on Ulterius possessed narrower blades than those Gell thought common. The colors were not the same, but then the two suns and the two atmospheres were different. Color did not matter.

Gell remembered vaguely that leaves grew bigger in regions with still air but was not sure that would explain the species and world differences. Besides, some of the Earthly sea grasses had wide blades, too.

In the distance, he saw large, shaggy, four-legged animals munching on the grass. Several looked at the humanoid robots as they passed but did not do anything else. Leestel noticed him looking. "That is a herd of bison," she said. "Herds can be much bigger, but we limited their sizes so they don't inadvertently cause damage. While walking from one place to another, a large herd can wear down the grass so much all that is left is soil."

"How do you control numbers?" asked Gell.

"Genetic engineering," said Leestel. "Individuals like being close to others, which increases the size of herds, but start to feel too crowded when they see vast numbers. Since control depends on what bison can see directly, the engineering succeeds."

"You did a huge amount of genetic engineering," said Gell.

"Well, every Earthly bug, plant, and animal needed some engineering," said Leestel. "In a vacuum, the surface of this planet would be cooler than the surface of Earth would be in the same circumstance. Fortunately, Ulterius has an atmosphere, even if it does not have much of one compared to what you are used to." She smiled. "This air has considerably more carbon dioxide and other greenhouse gasses than Earth. The planet stays warm. The extra gasses are enough to kill unengineered organisms. Organic humans and every other organic being need adjustment to survive.

"Smart, but non-sentient computers must engineer data packets. Getting that right is very difficult. But it is done. And complex forms, like those for bison, have changes done to them that can be modeled. We can't go too far; the models are not the best. That is why the process must be watched and corrections made when necessary. We try not to make mistakes but we cannot help them. Still, in not quite a gross of years, we have managed to go from a dead world to one that is nearly able to take care of itself.

"This planet was once completely dead. It depended for its carbon dioxide on weathering, volcanism, and the motion of continental plates. In terraforming it, the first step was to convert data packets into microbes that could be spread all over the place. Some, perhaps most, fell into inhospitable environments." Leestel waved her head back and forth. Gell was beginning to understand that was an unspoken communication. But she spoke anyhow, "A good number of bugs survived. They attached themselves to the surfaces of rocks on land and in the bottoms of oceans and disintegrated them. They created mulch. The next set of microbes made use of that mulch. Some time after that, a newer set created an oxygen atmosphere and killed off the preceding

microbes or most of them. Multi-cellular bugs succeeded single, microscopic bugs. Complex life followed. Shortly, this planet will take care of itself, changes will happen slower, and it will be ready for humans. It is quite amazing."

They climbed up the hill. Gell was pleased he was in a tireless robot body. He figured it could not have been comfortable in an organic body. 'Or,' he thought more closely, 'an organic body is adapted to this. After all, they evolved on a surface full of hills. Genetic engineering has not cut back their options as it could have.'

As they went higher, they penetrated groves of different species of tree. Leestel noticed him staring at one.

"Micro-environments." she said. "What?" he asked.

"The kinds of tree that grow best," she explained, "depend on the nature of the soil, the amount of water, the average temperature and its range. These features all change from place to place. That is why we use the term 'micro-environments.' They are calculated ahead of time — that is an important part of modelling — and the right trees are planted in each spot. As you can see, these woods did not come from trial and error or from an ecological succession. The woods are too clean. Even the process of succession will take grosses more years to become visible."

The top of the hill was mostly stone, although some had a green layer on it. "Lichen." Leestel said. "Look at the . . ." she paused for a moment. She was going to say 'city,' but it was not that big. "Look at the town." It was called 'Pamaitcas' or 'First City.'

The airport, a single runway longer than the town, came between it and the hill. A lake filled a hollow to the left. The town itself consisted of one and two storey buildings, all made from stone. Gell could see two quarries in the distance on the right.

"Sharmis," said Leestel, "the capital of Melior, is much bigger. It has mass transit. This looks like just one neighborhood."

"It is one neighborhood," said Djem, grinning. "Ulterius has few humans."

'Nonetheless,' thought Gell, 'the human population on this planet will be much larger than ours on our Jovian. How did they bring them all?' Gell was still thinking of slowed but living entities embedded in computers, not of dead data packets.

Next, the humans took Gell to the lake he saw from higher up. A lake on Ulterius consisted of water held down by gravity with a liquid-gas interface. "We have designed your robot body with enough hollow spaces," Tuppak said, "that if you inhale air, you will float on water, and if you exhale, you will sink. Such a characteristic is like that of a typical human body. Most inorganic substrates are denser than water

so most robots sink. But yours is supposed to be as similar to a human as possible."

Tuppak grinned. "We are not going to teach you how to swim in the water. It does not matter whether you fall in; you will not drown since you do not depend on air. Your breathing is simply to illustrate smell and floating. If you do fall into the water, sink. At first, your eyes will not focus sharply. But after a short time, your visual sensors will adjust to the different indices of refraction of air and water. So you will see sharply. That is a safety feature. However, the water may well be murky. You may not be able to see anything. In any event, walk to shore. Go in the direction your internal computations tell you.

"Organic humans almost always wear a transparent mask or goggles with air close to their eyes. That way, they can see sharply even though their natural eyes cannot directly adjust enough for water."

They walked along the shore of the lake. Gell had to admit the scene was beautiful. When he inhaled through his nose, he smelled humus and water. The colors of the green plants, the blue sky, the few white clouds, the darker reflection of the sky in the water — he knew the reflection was polarized, but he could not see it — they all looked good, even though this robot had a different, and much more limited, range of sensitivities than he did normally. Based on his understanding of the dictionary, although it never provided the knowledge specifically, the lake and hill were all the 'right' size. Gell was adjusting to the humans. They, their notions, and their geography were becoming less strange.

They came upon a dock and Djaeds took Gell canoeing. The dock and canoe had been constructed very recently. "As you get in," Djaeds said, "put your foot in the middle of the canoe and grasp the gunnels with your hands, one on each side. That way, you will balance."

Gell did that, and held up his other foot.

"Good," said Djaeds. "Put down the other foot in front of the first. Slowly walk forward.

"That's right. Move your hands and feet one at a time, and step over the seat. You are going to sit down on the seat facing forward. . . . Good."

Djaeds suddenly remembered that he had not been in a canoe since he was young on Earth. Since then he had come to Melior and come to Ulterius. He had been awake and alert for a long time. Nonetheless, he remembered. 'A wonder,' he thought. Djaeds climbed into the back of the canoe much more quickly than Gell had stepped into the front. Then Djaeds picked up a paddle that was sitting closer to him than to the front and passed it to Gell.

"Please take the paddle, lay it on the gunnels in front of you, keep holding on to it. Put the blade on the left. I am going to push us off,

and then paddle on the right. Please paddle on the left. You can see from me how to hold the paddle. I will steer."

Gell turned his body to the right and completed the look behind him by turning his neck. He saw how Djaeds was holding the paddle and turned front. His right hand grasped the head of the paddle; it was a quarter turn from the pole itself. His left hand went around the pole. Gell put the blade in the water, pulled back with his left hand and pushed forward with his right. That was like an old fashioned, oar-propelled galley on his home planet. The water swirled back. But Djaeds was not feathering the paddle when he moved it forward. Instead, when the blade was back, he pulled it out of the water and moved it forward through the air.

"If you leave the paddle in the water for the forward sweep," he said, "you have to feather it like this," and showed feathering just like oarsmen did on Gell's home planet. "Otherwise," Djaeds said, "you push water forward and cancel out a push in the other direction. We do that to slow. We paddle backwards to go in reverse or to stop the canoe and prevent it from hitting the shore or another object too quickly."

Gell nodded. It all fit an historical drama he had seen, except that the air was low density and movement of the paddle in it did nothing. The water had about the density of his atmosphere.

He did not fall in.

Chapter 12

Gell rode up from the planet on the rocket. He was the first tree tortoise to leave an inner planet. He arrived safely at the space station, somewhat relieved. 'These humans are certainly inventive,' he thought to himself.

Adkel proposed Gell view the organic laboratories. He had watched Gell on the planet and been persuaded by the other humans that immediate cooperation was best for the long term.

"Let's have Moel do that," Gell said. "She is going to manage our bioforming project. Although she can and does advise me, there will be less of a speed-of-light delay were she here herself." Also, although he did not say it, her presence would be a good test of the humans' friendliness. They might see her as a more important prize than he. The humans said they were not looking for prizes, but there was no way the tree tortoises could find out except by their taking risks and viewing the humans' subsequent actions.

Adkel said, "It will be several weeks before she can get here physically."

"So we wait," said Gell. Adkel was smart enough not to ask why she did not transmit herself by radio. The distance was interplanetary. Radio would be quicker than coming physically. Since Moel did not have to come very far compared to how far she had come between stars, there was more than enough bandwidth. He remembered the question for later.

Moel came. She did not feel as scared as Gell, possibly because she was second, possibly because she trusted the humans more.

On the space ship coming inbound, the only human was Telren; he did not look human. He had traveled to the planet with Gell, radioed himself when Gell asked Moel to come and entered another six legged robot in the planetoid belt. He shut down his babbo body on the space station. Now he traveled again to Ulterius. Neither Moel nor Gell thought to ask how Telren went from the inner planet to the planetoid belt so quickly. During the trip, he entertained Moel with numerous metaphors for taste and smell, some new, some recorded by Gell. He was careful to point out that his shape was based on a non-human animal although his metaphors were all human. Having moved to her new body, Telren said, Moel should follow human-shaped exemplars like Gell or Leestel.

Moel knew that each of the humanoid robot bodies was built slightly differently from the others. That helped distinguish one from the other. Before she had entered any human robot, she had asked for one that looked more like Leestel than the rest. "In our records, Leestel comes

across more similar to me than any one else," she said. "Was she originally female, like me?"

She explained to Telren, who was the human contact. Moel said, "We have two sexes. That is the minimum number to provide genetic mixing and the maximum number that is convenient. Can you imagine three getting together at the same time? It is hard enough getting two together.

"Among females, the sex organ is mainly on the left centerline between middle and rear fins and on the right for males, except a portion of tree tortoises have their organs on the other side. Indeed, their whole body is reversed; the sleeping and waking halves of their brain are too; I mean, they sleep or stay awake on the opposite side, then switch."

"How do males with sex organs on the left couple with regular females whose sex organ is also on the left," asked Telren.

"The male turns over," said Moel. "The act is not quite as pleasant as when both the is sex organs are on the same side, so couples try to match. But it is not unpleasant either. My hunch is that matching enables the characteristic to survive better than it would otherwise, but turning over prevents the evolution of two tree tortoise species."

Telren nodded. "Prevents speciation . . . probably true," he said.

"Other than females' bearing young, the two tree tortoise sexes don't have many differences between them. Some other animals have more."

Telren nodded again. "You are very like humans," he had said, meaning 'you as a species.' "Leestel is female. Everyone else is male."

Moel enjoyed the embedding; she liked learning human behavior. Smelling roses was not so different from what she had done in an organic body, except the tree tortoise equivalents of flowers was not the same. In both ecologies, those who could not move, the 'flowers' rewarded those that could, the 'insects.' The more advanced species in both, the tree tortoises in the one and the humans in the other, still had the recepters and a processing mechanism that made the molecules smell good. On the other hand, the human behavior of sitting in a chair was very different. As a tree tortoise, she floated, holding herself in one place with her rear fins and her lungs' jets. Since humans could not float in their air, sitting made sense.

On the space station, Adkel took Moel to place where organic human bodies grew. They walked to a room which was full of separate pedestals, each about one and a half meters high and two and a half meters long. The top of each pedestal was transparent.

Pointing through what amounted to a window of solid material, not like Moel's original windows, which did not have any solids at all, Adkel said, "These are organic humans. Their bodies don't think yet; they are in tanks where we force them to grow quickly. Humans not only look like this, as in pictures, they are this."

Then Adkel stopped. Moel took in the sight. They were growing humans who did not think. To her, that meant they could transfer the sense of self, all memory, from an inorganic to an organic body. She did not know yet about dead data packets.

She did see that all the human bodies appeared to be the same age. Indeed, although she did not have the word for it yet, every human body was adolescent. "They look the same age," she said, "that could pose a problem."

A nod came from the other humanoid robot. "Yes, good observation!" Adkel said. "Almost no one who is reborn wants to enter an older body. They want to enter a body that is two dozen terrestrial years old.

"In seven dozen terrestrial years, a larger than normal group should come from Melior. They will be the people who heard you exist. You should draw more than we expect to receive. After all, from our point of view you are intelligent aliens."

"They will have to wait until the Jovian is ready for us," said Moel. She was still considering the implications of inorganic to organic transfer. She was not sure how long a terrestrial year was, then she figured it out: a little less than one-sixth of her home years.

"Yes," said Adkel. "We are going to wake them anyhow. That group will be out of phase with those in these tanks being reborn a second time.

"None of this group are children — no one has children. On Melior, the first colonists did. They were reborn. However, they were not reborn into two dozen year old bodies, but into bodies the same age as they were. Their new bodies carried genetic improvements and the like. Except for fixes to deafness or poor eyesight, the children hardly noticed them. We did not provide any children with radio links or with internal computers."

Adkel continued. "Unfortunately, another big group that we expect to come will end up having the same physical age as the first. They will come in two standard lifetimes, when our people are being reborn for a third time. We have to spread out rebirths, since we have few helpers, but the spread won't be much. I expect this Melian group to come after your Jovian is bioformed and many of your people are reborn. They will find you interesting. That will be in a gross of terrestrial years."

Moel quickly figured that a gross of terrestrial years was nearly a double dozen of her longer home years. Quite unconsciously, she tried to flick the second and third lobes of her left forefin, but couldn't, since she was wearing a humanoid robotic body.

Adkel shifted away from alien bioforming to human. "As you have seen," he said — Moel had only seen the planet from orbit, but she had reviewed Gell's visit, "robots, most of them dumb, have prepared

this inner planet. We call it Ulterius and it is for humans. We will have human organic bodies ready in less than a terrestrial year. We can impress thoughts and memories on them. I don't think you can do that yet." Moel shook her head. "No, we can't," she said.

"We can also grow them fast. Indeed, we can grow anything fast. We can even speed up growth on otherwise dead worlds, although not as much as we can speed up growth in tanks. We will tell you how. Your biology is different, as it must be, but I expect we can figure out what to do. We have worked with non-human biologies, although none for your kind of planet. I am sure your people will figure out the technologies soon — maybe they already have on Xi Bootis and the radio message is slowly crossing the space to here.

"In any event," Adkel said, "we know the technologies and have had plenty of experience. We want to start out with you correctly. Cooperation is better than conflict. I was going to say, 'we want to start out on the right foot' but that expression works only when you are in a human or human-like body on a solid in a gas that you cannot swim or float in."

Moel nodded. That was the filler she used when she did not have words to say. She felt triumphant. 'Cooperation is better than conflict.' That was true. She was in a human-like body on a solid in a near vacuum, but she did not think of that.

Adkel's comments also explained the speed at which the humans were able to finish the bioforming, which the humans called 'terraforming,' or finish the beginnings of it.

"We should be able to speed up your bioforming," he said. "We do not know exactly what is involved, but it should not be too difficult. Still, you should wait a gross of years. Rather than the small and nearly barren trees that would grow at normal rates, they will grow bigger and lusher. They will not be huge, like the old trees on your home planet; they will not have grown enough. However, they will have empty spaces inside in which you can hide and in which you can bring up children. People will be happier."

Moel nodded again. In order for Jovian biology to grow faster, the humans would have to learn details. They could be used for attack. On the other hand, the humans would learn everything at some point anyhow and evidently wanted to cooperate.

At that point she exploded. It was not a very powerful explosion; just enough to kill her.

Radio signals had triggered her. Adkel was shocked. What was going on? He himself had never seen an explosion, although he had memories of explosions and knew how to make explosives.

Gell called immediately. Moel had been transmitting everything she saw and heard through the meeting and Gell had been paying attention.

Moreover, just as she was exploding she transmitted a signal that said the explosive was detonating. He asked, "What happened?" There was nothing that suggested the humans were being evil. But the explosive would not detonate of itself, either.

Adkel responded, "I don't know. We don't wire ourselves with explosive; why did she?"

"At home, before we traveled interstellar, the police insisted we be able to prevent anyone from successfully kidnapping us. That is why the explosive is there. No one took them seriously, since no one expected to find intelligent aliens. We, all the interstellar pilots, thought the police were being excessively paranoid. Since the bombs don't go off on their own — the explosive and its control is a very old technology — none of us thought twice. So, something in your radio environment must have set it off."

Adkel said, "We will look into it. At least, she is not dead."

"What do you mean, she is not dead?" asked Gell. He nearly cried. "Of course, she is dead. I have not recognized that, yet."

"She was backed up. It is easy to do that with an inorganic. She should not lose more than a day, and since she knew she was coming here, less. Surely, she was backed up?" Adkel was starting to believe she was not.

"No, she was not backed up. We never do. I don't know what you mean," said Gell.

"How do you transport beings between stars?" Adkel asked.

"By carrying them as slowed down, sleeping people in a computer. I was the only person awake during the trip, slowed down, of course; but I was the only person with individual access to manipulators, too. Being unable to act, except jointly, even if they woke and could see, which they could, that would be torture, especially to the pilots, who are accustomed to doing things."

"We carry people between the stars as dead data packets," said Adkel. "Even computers like me" — that was the second time Gell had heard that one of the humanoid robots contained an intelligence that was not originally biological, but the information passed him by — "even intelligent computers are turned off and transferred to data packets. We can be transferred back and get turned on quickly by a smart, but non-sentient machine that is not bored by the years of nothingness that an interstellar trip requires. Basically, we are turned off. For us and for the organic humans, a trip is quick, or always has been. Dead data packets don't take up so much room as a potentially thinking computer, either. Did you carry all your passengers in computers?"

It did not occur to Gell that he was providing the humans with enormous information when he said, "Yes."

"When you transfer from your organic body to your first inorganic body, on your planet — that transfer happens immediately, right?" asked Adkel.

"Yes," said Gell. "We fall asleep as organic entities and wake up as inorganic. We ride into space. Even with sensors and manipulators, we don't mass much. We leave the planet."

"So, am I right in thinking that you have been slowed down, been sleeping, but never been turned off or 'dead' in your whole life?" asked Adkel.

"Yes," said Gell. "How can it be otherwise?"

"I was going to ask you that question, with contrary presumptions. It is easy to back up or duplicate robots. For organics to back up or duplicate is not hard, but it takes longer and there is more chance of a death forever. At least, there is more chance the first time, before we have made a data packet. We make duplicates of the dead data packets. Then you may lose the time between backups, but no more."

Adkel also understood that with the appropriate technology, Moel could consider transmitting herself by radio the next time, so long as she did not prevent herself from doing that by belief, whether or not it could be proved.

"We don't plan to rebirth any of them, but when we came here, we brought copies of all the Melians' data packets," Adkel said. "If something goes wrong on the other Melian planets, something that destroys even the packets stored in deep space distant from the central star, then we can rebirth them here."

"You mean a nova or something like that?" asked Gell. "Yes," said Adkel. "Presumably, that kind of destruction would have to be triggered by a much more technically advanced alien species. We don't think a nova would be natural in G-type stars of the age of this or of the brighter component of Xi Bootis.

"Whatever you might have thought," Adkel figured Gell had calmed down enough, "Moel is not lost. She has been backed up fully. I just checked. Indeed, I suspect it was an automatic backup that triggered the explosion, though why the explosion occurred is something I don't know. Why that radio signal did not effect you, is another question. Backups don't get run all the time, but for robots the time between is a day or less."

"I have circuitry to handle unexpected radio inputs," Gell said. "We put in extras because we were not sure what an exposed observer would find between stars. I was, after all, alert, awake, and observant, albeit slowed down. However, nothing could get at Moel and the other sleeping spacemen without coming through the space ship, so they did not need those extras." He paused for a moment. "The explosive circuit takes a short time to go live; the police thought that no one could copy a mind

in that time. Are you saying the bandwidth was high enough that you could?" "Yes," said Adkel. Gell added, "My extras carry mass as well as information. Their existence among the rest would have meant carrying fewer people."

"I see," said Adkel. He wondered why no tree tortoise employed radio. "You don't have any belief about a noncopyable part of the person, do you? I don't see the concept mentioned in the dictionary you provided."

He explained. "Many humans have such a belief; they call it a 'soul'. They worry that a soul will not stay with the dead data packet and enter the mind when it reanimates. None of our people, of course, were worried enough to forgo the migration from Earth to Melior or from Melior to here. But Djem, for example, was brought up badly. He did have that worry when he first came alive again on Melior. However, over time, he discovered that he did not feel any different except for the improvements we made for his new body. Even though the existence a 'soul' is not verifiable, I think that discovery relieved him. He did not truly believe in something he could not experience one way or the other."

"No, we don't have that belief," said Gell, "at least I don't and I doubt that Moel does. How could you transfer yourself to an inorganic substrate if you did?"

Adkel laughed. He was careful to indicate that he was not laughing at Gell, but at other humans. "You made a good point. That belief is why many humans desire to be reborn with an organic brain even though it is so much less convenient than one like ours. Humans are often irrational. You cannot do much about that. We Melians are self-selected Utopians. Even so, most Melians do not wish to be reborn inorganically, unlike the people you have met."

He shrugged. "Since it was possible, I only rebirthed people who had said earlier that they wanted rebirth in an inorganic brain. They were surprised to find themselves in humanoid robot bodies, but I had not grown organic bodies; I still have not grown them enough. Every human is going to be entirely inorganic for a while longer."

"Your inorganic humanoid robot bodies don't look as complex as the organic human bodies that Moel saw growing," said Gell.

"No," said Adkel. "We could make the robots look more complex. We could make them look just like humans. But we don't. There is a law on Melior and I see no reason to change it. The law says that a very young organic human, say four terrestrial years old, should have no trouble distinguished a humanoid robot from an organic human."

Gell converted quickly. Four terrestrial years was less than two-thirds of one of his home years.

"If you want to look like an organic human, most of the body should be organic. Of course, the mind might not be. And the processors of the mind might not be in the same location as the body. That applies both to organic and to inorganic bodies. My processors, for example, are not co-located with this humanoid robot body."

"Your mind is not part of your body," said Gell dumbfoundedly.

"No," said Adkel. "I run this space station. It would be inconvenient to put my processors in this robot. But all the rest, including my duplicate, Aglar, carry their processors with them in their bodies. For one, they don't have to worry about speed-of-light delays."

"Aglar is a duplicate of yours?" asked Gell, who had not put the sentence in proper question form, but made it a question anyhow. He was still being surprised.

"Yes," said Adkel. "You went out towards the Jovian. You stopped in the planetoid belt a bit closer in than we anticipated. That stop makes sense. It is a good place for your assemblers. But still, you are light minutes away from here. I could give advice, but there was no way I could operate out there and handle emergencies on this space station, too. Not that we have many emergencies, you understand, but I have to be ready to deal with them in real time. I have to be here. So I duplicated and made Aglar.

"I could make a lot of duplicates. The process is easy. The hardest part is thinking up names. But, soon enough, each duplicate has different experiences and becomes his own person. You can make duplicates, but you cannot unmake them anymore than you can unmake yourself. Well, you can merge with a duplicate shortly after creating him; then you have two sets of memories, and that is that. But you don't want to make duplicates of instances with whom you don't merge. Those instances will be around for ever and ever. They will clutter up space."

His robot face grinned at Gell, who understood the smile. "You could duplicate, but I would not suggest more than once. I am not sure you would want to do that."

Gell rocked back. He had not realized that he could. The discovery changed his whole sense of self, but he was not quite sure how. So he shifted the discussion. "You can resurrect Moel?" he asked or perhaps stated.

"Yes," said Adkel. "The backup data can go on any kind of inorganic computational substrate, human or tortoise. We might even be able to put her onto an organic human body and keep her sane, but I don't think she would like it.

"We, that is to say, assemblers, are building an inorganic container for her that is similar to the one you pioneered. It is small, rectangular, with manipulators and sensors, and with connections for getting information from and for controlling a humanoid robot." Adkel became

more specific. “At least, it is similar in its outside looks. Its interior will carry human computer hardware, no explosive. You can provide an inorganic container of your own; she or you might prefer that. However, getting one of your containers here will take some days. There is no reason to wait so long.” He did not expect the tree tortoises to radio the instructions and did not ask.

Adkel continued. “After she is embedded into a small inorganic container, we can put it into a humanoid robot that is exactly like the one she had before and wake her up. The jump in location will tell her that something happened. We will have to explain it. She will be able to access this conversation. That is one of the reasons for it.”

Chapter 13

Gell spoke to Tuppak. He liked Tuppak. The man wore a babbo body with six appendages. Gell himself was in a human body. Tuppak was more a tree tortoise than the four appendaged humans.

Tuppak could use all the appendages as legs, although he didn't. He tended to walk on the back four and use the front two for grasping. That was like tree tortoises, who used their middle and rear fins for swimming and their front for grasping. Telren, Gell noticed, often used all six appendages for walking. At other times, he used the front two as hands and stood or walked on the back four.

As far as Gell was concerned, Tuppak was more intelligent than the other humans, even if he did not fit into a babbo body as naturally as Telren. At least, Tuppak appeared to understand tree tortoises better and was sympathetic towards them.

"Our original boats were people-powered galleys." Gell meant 'original miltary boats,' but Tuppak was not confused for long. "That is what Alguldintirn invented. He was not renamed 'Tirn' until later. Each galley was propelled by two double-dozen rowers and carried two double-dozen warriors.

"At first, ship builders knew only to bend wood into hoops or circles or cut them straight. They could not construct any other shape. Years later, they figured out how to curve longitudinal struts into parabolas. We have a replica of one of Alguldintirn's galleys in the entrance tunnel to the central government; its construction contains only circular curves and straight pieces. It is accurate."

Gell continued. Tuppak looked interested. "On the back cone, where a galley's girth grows smaller, the replica has a bottom door stand open with its hinge at the edge of the cone and the wide part. It shows — well, I presume it still does; I have not seen the replica for many years — it shows or showed six swimming warriors come out. Initially that bothered me," he said. "Presumably, if the rowers were feathering as shown by the replica, the galley was moving fairly fast. I did not think that soldiers would have left. I was wrong."

Gell found that the first galleys did drop off warriors when moving. They spread out. It was several generations before military policy changed. Then galleys stopped and the warriors exited all together.

In that same change, warriors gained shields. They were provided as standard equipment by what was now called 'Tirn's tree,' although he was long dead. Each warrior held a shield in his left forefin and wielded a sword in his right forefin.

Gell explained to Tuppak, "By the time warriors began to carry shields, they were paid even without war; they had become a permanent and well trained group. None of the opposing trees did this."

He went on. "Tirn tree warriors could and did form together a nearly spherical 'hedgehog,' as they called it. Those 'warriors' came to be called and saw themselves as 'soldiers.' Soldiers cooperated more than warriors."

None of Tirn's tree soldiers liked the rear of a hedgehog, since they had to swim backwards and pull a shield whose streamlining faced the other way. Those on a side had to swim sideways. They did not like the tops or bottoms either, since they not only had to swim sideways, but were vertical as well. Fortunately, their commanders understood. Even the dumbest leaders followed the procedure that said soldiers should exchange position every week. Although mathematically, a sphere could go in any direction, in practice, in combat, a soldier needed only remember how to stop, how to swim, and how to turn a little. When a change in direction was necessary, the whole sphere turned slowly.

Attackers who swam around to the hedgehog's rear found that the soldiers there were as dangerous as those on the front and grumpier.

"Shields did not quite overlap and swords were not terribly long." Gell explained that a swimming beast with a lance strapped in front could push back any soldier in any hedgehog. "But even a sharp lance," said Gell, "would not kill a soldier. It would only go into a shield a little ways."

"What about soldiers who did not move their shields correctly?" asked Tuppak.

"Some were killed; but only a few," said Gell.

"When one soldier caught the lance on his shield and was pushed back," he said, "the beast ended among the flankers. So, usually, did the knight it pulled. The knight had reins and could see around the lance. The flankers cut off the beast's fins, an effective but dishonorable action, and then stabbed it to death by finding weak boundaries in its armour. If the knight stayed, he died, too, although he might also kill several hedgehog soldiers in the meantime. If he swam away, he was not killed and was not pursued. But he was not in the fight, either."

Tuppak said, "In modern conflicts among humans, many civilians and few soldiers die. That is a side effect of modern technology."

"Yes," said Gell, "the same applies to battles fought by modern police. In Tirn's time and for many generations more solders died. A good many civilians did, too, now that I think about it. They starved or succumbed to malnutrition-induced illness."

Gell explained another tactic. "In the past," he said, "when enough beast-pulled knights cooperated, those in the middle could penetrate the hedgehog. In it, they could fight and win.

"But," he said, "such cooperation was infrequent. Many knights died. That would be those on the outside of the attacking group. While

one flank would consist of other knights, the other would consist of hedgehog soldiers who would cut off the fins of the pulling beasts.

"Moreover, as I said before, unlike the soldiers of other trees, soldiers from Tirn's tree did not kill those they defeated. They merely disarmed them and sent them home. Even though it was humiliating, many knights thought it better to be alive and be defeated rather than be dead in what many would consider a useless war. It was not a huge risk for Tirn's soldiers."

He completed his remarks: "The last trees did not fight. They knew they were outnumbered by the rest of the planet. As soon as possible, they surrendered their independence. That is how we got a unified government!"

Chapter 14

Within a relatively short time, the organic human bodies were grown and migrants were reborn into them. They learned the news from Melior, not that there was much — they were behind because they had been traveling as dead data packets at one-quarter light speed — and the immediate and important local news, the arrival of aliens.

No human cared about changes to Nebber, the Jovian, or at least, not enough for the changes to become public; it was dead and would become alive. However, a few of the reborn feared the aliens will take too many space resources. Not only did they fear the aliens, they wanted humans to expand quickly. In that sense, they were expansionists. However, on Melior few had been in the 'Expansionist' party, almost all had been in the 'Earth Beware' party.

As a diplomatic solution, Djem suggested the humans and the aliens sign a treaty — a written statement — that neither species would ever use too much of the system's space resources. Leestel agreed.

"You will have to become accustomed to different humans having different opinions," Djem said. "That is why we have central decision making."

"We have factions, too," said Gell. "You humans are like us. We may be seeing a characteristic of every species that communicates in a language. Perhaps every intelligent species has individuals different from the rest, even those hypotheticals whose technology far exceeds our own."

"Two is too small for a sample," said Djem. "But in one sense, I am happy that you have factions, since it means you can understand the problem. In another sense, I am not happy. Factions can be dangerous. With advances in technology, smaller and smaller groups can hurt others. Once, only states could afford to pay for destruction. Now, you don't need people. Assemblers can build anything, including weapons.

"I suspect," said Leestel, "the 'Aliens Beware' people are afraid of what can be built by assemblers. But they do not want to say that besides using up too many resources, a group of you might attack.

"Fortunately," said Djem, "the problem is no different from the added use of resources by other humans or from the fear of an attack from them. When you have assemblers, you must follow three paths simultaneously: resilience, so nothing harms many people; material equality, to remove a source of envy or humiliation; and political legitimacy, so adults see justice.

Djem stopped for a moment. "The Melians also have widespread computer monitoring," he said, creasing his brow, "but they have not let it become abused by the corrupt or crooked or those who believe it

might be useful. On Earth, one or the other or all three of those groups control monitoring. Fortunately, it is not as extensive as on Melior.

"When I was on Earth, we didn't permit replicating assemblers. Indeed, their existence was a successfully kept secret. I did not know of them at all. While I was not senior, I was successful enough. Had assemblers been widespread, as on Melior, they would have made material life much easier. I know what I am talking about. When I was an Earth-bound civil servant, I focused on material disasters.

"Assemblers would have made it easy to extend monitoring. After all, with atomic replication, sensors and the computers that go with them simply become more to be duplicated. People far more important than I knew about assemblers. However, those leaders kept their existence secret and did not use those they had. They must have been very afraid of dangers."

"We tree tortoises," said Gell, "have had assemblers for a long time, longer than you humans. They have been controlled by the government. We have had almost no abuses that I know of. I think that is partly because abuses occurred before assemblers." Gell became sardonic. "Abuse does not require advanced technology."

He went on, "Also, trees are more independent; the tortoises on them make up what you would call an extended family or clan, except the people aren't necessarily related. However, the central government does not permit every tree to manufacture every material object, although with assemblers, they could. That means there is a cost for material goods as well as for status, attention, and power."

"In human terms, that kind of set up is unstable," said Djem. "Cheaper material goods that are produced will eventually drive out the more expensive, even when governments try to restrict them. That happened with information. A government will succeed only by banning production altogether and only what people don't much care for."

"Yes, for you" said Gell. "On my home planet, we have had a single, stable, central government for much longer than any of yours. The people who run it are not too corrupt. I am reminded of your anthropology studies: among us, children learn that the center takes more, see that as a 'natural right,' and as adults do not see that as corruption.

"Regardless, even early on, members of a tree tortoise central government were less incompetent than members of a human government. Our leaders could safely select from the complete population of a whole tree. In other words, the clan was bigger. Also, governments selected employees by examination. Since there was no military threat after the conquest, and since trees controlled themselves, the army became, in effect, an inter-tree police force. In the police, a different kind of individual became successful than when it was an army of conquest."

"This took a long time," said Djem.

"Yes, but as I said, we tree tortoises change very slowly. Children learn all they need when they are growing up. Or at least, they have. It is you humans who cause rapid change.

"I'll sign that treaty," Gell said suddenly.

Chapter 15

Tuppak provided Moel with genetic modifications that he and the AIs thought would speed up growth in the Jovian's new biosystem. They thought they understood alien genetics, biology, and ecology well enough.

They were wrong.

Moel tested the modifications on small bacteria and little trees that she had floating in small, strong chambers that she had her assemblers build. The chambers did not explode, even at pressure.

With single species or just a few, the modifications succeeded. When the appropriate chemical was added, and the other resources were available, growth sped up. But with a large concatenation of different species, as would happen in nature, the modifications failed. Even under the best circumstances, they did not cause the bacteria and trees to grow any faster.

At least nothing died. Tuppak was glad of that. But he and the other humans were mystified. Why didn't the engineering succeed? Most of the humans deferred to him and the two AIs. The others could get the information quickly enough, but had not spent years thinking about it.

Tuppak suggested experiments. Moel set them up. The results did not end Tuppak's confusion and deepened Moel's. She had thought she understood the modifications and now she found she did not. She only understood their intended purpose, to speed growth and then to return it to normal at the right time.

The intent was straightforward: to increase the growth rate, robots would release small amounts of a complex chemical that was not produced naturally. That chemical would trigger the genes that would cause the cells to grow more quickly. Alone, or in small groups, that worked fine. The alien cells responded as expected. The difficulty arose when a large number of different species interacted.

Tuppak said, "The problem must come from an unknown interaction between the genetics and the ecology. Somehow, we are losing the expressions of fast growth signals. They are being turned off."

He thought for a moment. "To discover, we will need more experiments and more sensors. Some will be complex."

Moel nodded — she was in a humanoid robot body since the humans had suggested the fast growth modifications and she wanted to be polite. Tuppak had not noticed, but then again he was not wearing a humanoid body. At the time, both were in free fall, but stayed in one orientation. Their feet held onto what looked like a rug with special mechanical connectors. Tuppak only made use of the connectors on his four back feet. He used his front two feet as hands and never thought of them as legs. Since he was in a babbo-like body, it would have been

straightforward to use them as legs. Without acceleration to clamp him down on the floor, a myriad of little, flexible hooks would have poked out of the two front appendages.

"We will need larger chambers, too," she said. "We will have assemblers build them," said Tuppak, "along with a decent space station. That is an advantage of being in a planetoid belt; there is enough material relatively close by. It is not at the bottom of a deep gravity well." Moel understood what he meant by the word 'well.' It was a hole in a solid. That she knew about. But the 'gravity well' metaphor depended on an atmosphere that caused almost nothing to float. Going into space took enormous energy; floating took less. She understood that a fluid provided support and that the human atmosphere offered little. Nonetheless, even in a humanoid body, she would never have thought of making a metaphor, like 'gravity well,' that depended on what to her was a very thin atmosphere.

"For convenience," said Tuppak, "I will ride a telepresence robot in one of these new chambers. You must have good designs for a fairly small one with manipulators I can use."

"Ours look like us, I mean our natural selves, except for being much smaller."

"That's fine," said Tuppak, "I want to learn your habits eventually, and this is as good an introduction as any. I suspect it is easier for us humans than it is for you. We have underwater swimming for comparison. You always float, on a planet or in space."

"That is except when we are in a space ship accelerating."

"Yes," said Tuppak. "However, when you are in such a space ship, unless you are with humans, you tend to be a part of the space ship and not an entity stuck to its floor. You don't depend on the acceleration to stay down the way an entity in a thin atmosphere depends on gravity."

"That's true," said Moel.

"Hmm," said Tuppak, looking through his copy of the dictionary from the aliens. "Your miniature robots have visual, auditory, smell, and feel sensors, just like you, but no taste sensors.

"Yes," said Moel, "robots don't need organic energy inputs, food, and our robots don't have mouths or stomachs for pretend eating. The test chambers will not provide food either."

"No, that is just as well," said Tuppak. "But I take it the rest of the robot's sensorium matches your own?"

"Yes, more so" said Moel. "As a practical matter, the robot's sensorium is larger, or can be made larger. Even the miniature robots can sense more. The main difference, besides no eating, is that our telepresence robots have their eyes and ears closer together on account of their being smaller. Consequently, they do have less of a binocular effect."

"We will be looking close by anyhow, so it won't matter," said Tuppak. "When it is constructing a three-dimensional image of the surrounding, does your mind take into account haze in the atmosphere between you and the object as well as the motion of nearer objects when you move your eyes?"

"Yes. Indeed, some have argued that for tree tortoises a second eye serves primarily as a spare. I am not sure how convincing that is, since eyes are on the opposite sides of our bodies and their sight does not overlap as much as yours. On the other hand, humans do not see behind them. Each human person suffers a huge blank area, yet as a species you have been successful."

"We know that survival and reproduction depend on a multitude of factors," said Tuppak. "Having a spare is just one of them. Multiple ways of determining distance provide different ways to use an eye. Interpersonal cooperation is important, too, and does not depend on eyes."

Moel returned to the prime subject, looking serious. "In any event," she said, using the same phrase as Tuppak, "you will want to connect to the other sensors as we do the experiments. But I will make sure we both enter robots who have an old fashioned, tree tortoise sensorium." She changed from serious to happy and grinned. "I will enjoy that!"

Tuppak said, "Fortunately, I am used to the kind of wider visual sensorium that you have. That comes from my experience with AIs, who hardly ever make do with the limited sensorium of regular humans."

Moel wondered about human AIs. What were they like? She did not know that human AI art existed or that its most common visual range was closer to her natural range than to human's. All the information was readily available. She did not know to turn her mind to it; and no one else had thought to direct her.

Tuppak kept speaking, "Still, the regular human sensorium succeeds. It won in the past. It is or was enough, although I must confess, I really do like the technological extensions that have come along. For progress, we humans needed eyes that work even past middle age. What we called 'glasses' provided that early on, but not as early as you might guess. Your eyes don't have lenses and you don't have the problem. In the end, although it took an amazingly long time, people invented magnifiers and telescopes. Even later, they invented sensors for the infrared and the ultraviolet. And they invented more. I like them all."

He paused for a moment, "Not every human does."

"Not every tree tortoise does either," said Moel. "But all us space people do. I suspect that you humans like space people, you who have inorganic substrates."

"Yes," said Tuppak, "as far as I know. The only person who might not is Djaeds, and I don't think he cares." He looked at Moel. "Thank

you for being who you are. I would never have thought of this sensorium issue otherwise." Moel smiled.

An alien assembler built the pressure chamber Tuppak was to enter. It was spherical and mostly metal, thick metal. Places had the occasional insulator, which enabled electromagnetic signals to pass. A conductive metal would have stopped them. Gas at the density of water — that was high pressure.

A big enough mass gravitated sufficiently to bring gas to that pressure, but the amount of material was many, many times what they could collect.

On the other hand . . . Tuppak reconsidered: assemblers could bring together what was necessary. They could collect enough, but would have to go beyond the planetoid belt. That would take time, a noticeable amount of time. Tuppak had never considered time. After all, assemblers could duplicate rapidly. They produced what he wanted quickly enough. But then, he had never wanted to assemble a Jovian planet.

He still did not want to. Moreover, he decided that the original presumption was right, tree tortoises should not build space ships to carry organic beings. Without a large, gravitating body, gases had to be held in from the outside. Hence, thick walls. They were heavy and less secure than the inorganic substrates that spacegoing tree tortoises lived within.

Tuppak had thought about genes and ecologies more than anyone else, human or tree tortoise. Adkel was a good second. Aglar was, too. Since he was a duplicate of Adkel, who had terraformed Ulterius, all Aglar's earlier memories included that experience.

The chamber Tuppak planned to enter was big enough to provide a fairly complex ecology. Most likely, he thought again, the ecology was turning off those aspects of the genes' expression that was supposed to provide faster growth. Tuppak wondered how. He expected many causes, as well as causes of causes. No ecology is simple.

Moel, Tuppak thought, was third in expertise or fourth if you thought of Aglar as different from Adkel. She had not made any of the mistakes he had made and he had made dillies, but she lacked as much experience as he or Adkel. He thought of the matter as a complex signalling problem. He considered the physical information carriers, the genes, as a medium.

He knew that an ecology was complex and therefore strange. Natural systems were always strange. Tuppak remembered the old textbook example, which really did not have that much to do with ecology, but did indicate strangeness: human eyes had their signal carriers in front of the cells that detected the photons, rather than behind. Who would have thought that? The signal carriers were transparent. Tuppak prefered

the eyes of an Earthly octopus. Their carriers went behind the cells. Light did not have to go through them to reach the detectors.

Doubtless, tree tortoises were strange in different ways. Tuppak thought he understood them, but didn't. Why did they have flippers in front of their eye and ear stalks? They used forefins as hands, but they did not provide motion the way the rear and middle fins did.

He had information about tree tortoise information carriers, their equivalent of Earthly genes. They were as small and as material as Earthly or Tegmarian genes, but were unlike them. He thought of more than tree tortoises; he thought of multiple species, of a whole ecology. Arrhenius spores had not seeded the tree tortoise planet, at least none from Earth, Tegmar, or Farhaven. The genes were different.

Tuppak had no trouble entering and riding a telepresence robot in the high pressure chamber. It was no different than riding a tree on Tegmar, except that the robot was intended to duplicate a rational being. He swam in a high pressure atmosphere.

The tree tortoises did not have any statement like 'The cat was on the mat.' That sentence presumed an atmosphere that did not hold up both the cat and the mat, an atmosphere with little lift. Instead, a tree tortoise pet floated and swam.

Among the trees, every large animal looked more or less like a fish on Earth. That was a consequence of convergent evolution. More children survived and had more babies when they had a streamlined, fish-like shape. Unlike humans in most lands, which did not have monkeys or apes, tree tortoises did not look that different from other animals.

Large animals had six fins, but except for tree tortoises, they all had eye and ear stalks in front of their forefins. They used their forward fins for steering and motion. Variation or mutation could put forefins in front of the eye and ear stalks of ancestral tree tortoises. When they were born in an isolated group and enough survived to mate with each other, the trait carried on. Those proto-tree tortoises would not be able to swim as fast as their predecessors, nor would they be able to catch as many other animals. However, if they were omnivorous, they would be able to grasp fruits in their forefins and eat them. Before they changed, when they had eyes in front, they must have gobbled fruits, not grasped them. Over generations, even before their forefins went to the front, good enough eyes to see ripe fruits, eyes that could distiguish colors, would have been selected to ensure survival. If the tree tortoises were near a tree, they could hide in a cavern when danger came.

On their original planet, Tuppak thought, the big early difference had to be grasping. First, the ancesters of tree tortoises would grab fruit. That would be a generative niche. Then they would hold themselves with one forefin, grasp a stick with the other and poke it down a hole. That would be an advance. Being omnivorous, they would still

like meat. Then would come language. Those who could talk with grammar as well as vocabulary could convey complex notions. They did not simply say 'food in hole' but could tell others what to do when a den had numerous exits. Or one tortoise could convey to a group how to cooperate.

Tuppak reviewed more. Not every large animal looked like a fish. Some looked like an octopus. So he could not say that every large animal looked like an Earthly fish. However, they all looked like underwater creatures. Even counting only those large enough to be seen with an unaided human eye, that made a large number.

Tuppak looked around the chamber. It had a glowing floor, dark walls and ceiling higher up, and a bright light on the ceiling.

Tuppak noted that the floor would have looked dark to a human. The core of the tree tortoise Jovian was hot, but not that hot. It glowed only in the tree tortoises' vision.

Doubtless — he thought again to himself and doubted — then he thought yet again and decided he was right: a crude, poor quality eye served to distinguish up from down for a distant predecessor of a tree tortoise. 'Down' was the direction that glowed. Up was the part that was dark except for a confusing, moving spot that would later be called the 'sun.'

Even without resolution, color enabled an animal to separate the sun from the planet. The planet and the sun glowed most brightly in different colors. If it contained a chemical that mainly detected the sun, a very poor eye could determine day, night, and which way was 'up'. Such a chemical might be a sensor equivalent of xanthophyll on Earth, a photosynthetic pigment that absorbed a yellower color than chlorophyll.

High resolution as well as color enabled a swimming animal to distinguish foods from potential predators. Bodies with different eyes had more or fewer children. That is another way to say they passed on their blueprints, their genes, differently. Improvements stayed. Those with poorer quality eyes had fewer children. On average, eyes got better over time.

Tuppak figured that binocular vision came about because bilateral symmetry is technically easy, whether done by a single engineer like himself or by a random process with fixation. In nature, doubling mostly requires duplication. He remembered that it needs other changes, too, but in an ecology, within a relatively short time in geological terms, a being with two functioning eyes will be born. Tuppak knew that a geological era contains a vast number of lifetimes, but planets had the time. Only short-lived individuals do not.

Two eyes provide for a spare. Those creatures with two eyes will have more children than those with one. When grasping becomes possible, two eyes provide for good distance observation.

Tuppak liked this body. It was better adapted than a human body to floating in free fall or in a fluid of the right density.

Humans in space mostly lived in spinning space stations or accelerated in space ships. Everyone, even AIs who should know better, thought of the purpose-built, zero-gravity robots as strange. They were different, no doubt about that, but maybe they should not be considered strange.

Of course, metals, stones, anything denser than the atmosphere, wanted to go to the bottom of the tank he was in, just as anything lighter wanted to go up. That was realistic and unlike free fall.

Human assemblers had built the spinning space station; tree tortoise assemblers had built the chamber inside it. The acceleration was not much compared to any on or near the surface of any Jovian, but the spin in the habitat holding the chamber was enough. Tuppak suddenly understood it was designed to be equivalent to the acceleration on the surface of Ulterius. The construction robots, the human assemblers, needed a value.

Tuppak was slightly bothered that the tree tortoises felt more possessive about material objects than he thought warranted. Indeed, Moel had her own assemblers build the chamber and fill it. Tuppak did not argue at all, since it was not an issue for him. But then, unlike the humans, the tree tortoises had not duplicated the information of any of themselves. Alive, they rode computers. For interstellar transit, they slowed, but they were in computers. They were always alive. Greed and life: two ways the tree tortoises were less good than humans.

Most of the tree tortoise computers were smaller than human computers. The entities in them slept very slowly. They had no individual sensors or manipulators; they were shared. Tuppak knew that sleeping entities did not need them at all. He supposed the worry was that the tree tortoises might wake unexpectedly. In fact, Moel and the other alien spacemen had been woken into larger bodies with their own sensors and manipulators. None were in data packets that stayed dead unless brought alive.

From Tuppak's point of view, the tree tortoises colonized other stars the wrong way. Nonetheless, he was impressed. They had done it. And he was sure that in an emergency, given enough time, even in small, slow computers without easy access to manipulators, some would wake and help. 'Maybe it is not the wrong way to expand the species,' he thought.

The human species as a whole had not cared about colonization. Those who did care — they were under threat if they stayed — un-

dertook what amounted to a high risk operation with high rewards if successful. Tuppak had done that. He was glad to have received the high rewards. Sadly, Fermi's Paradox suggested that the high risk ventures of other species ended in disaster although by its very nature a 'Great Silence' would not tell.

Tuppak practiced moving, turning, and grasping in his tree tortoise-like body. It was not difficult. Of course, he wore a six appendaged babboid body. Four appendaged humans might find the middle fins surprising.

Would it be easier to shift from a human body to a tree tortoise body or vice versa? Tuppak wondered. He thought it would be easier to shift from human to a tree tortoise: in addition to walking a human would be accustomed to swimming. The tree tortoise would never have walked.

Still, Tuppak was pleased that Moel planned to handle the equipment. He knew that until he had more practice in this body he would make mistakes.

The first experiments confirmed what Moel and Tuppak already knew: the modified bacteria grew in a complex ecology, but no faster than before. The second set of experiments told Moel and Tuppak that there was no simple cause. Both expected that result, but they checked to make sure. At least, they were confident that the fast growth expressions were turned off.

The next set of experiments investigated causes of causes. They narrowed their search by looking only at the causes of causes that stopped fast growth. It took them enough time for Tuppak to become well practiced. He also became gloomy. The tree tortoise ecology contained stronger negative feedback loops than he expected. It was intrinsically stable.

Moel was as happy as could be. She was learning all sorts of new things. Then, through a combination of her experimental acumen and his insight, the two discovered a third level cause. By making one change that looked completely unrelated, they got fast growth. And that growth had fewer bad side effects than anticipated.

Tuppak and the AI agreed with Moel that the Jovian could be seeded with the faster growth entities. Removing the added chemical would slow the growth rate to normal.

Chapter 16

After spending more than a dozen terrestrial years in the new system, Gell decided to go to Melior. The news about the humans had not even arrived at his home planet; that would take another four terrestrial years, almost two-thirds of one of his home years.

Even though the humans did help speed up bioforming, it would still take a long time. He could slow down. Originally, he had planned to do that. Moel would do the bioforming; she was competent. Going to Melior would involve a slow down, too.

Gell became more definitive. He said he would go. Like his trip from Xi Bootis to Ulterius, he would have sensors and manipulators. His interstellar vessel would be similar to the one on which he came, although it would be a different instance. It would be made by tree tortoise assemblers; he felt uncomfortable with human assemblers. He would go to Melior, spend time there, and come back in time to go down to his new planet.

And if he left, Rill could take over running the whole project. That tree tortoise did well. In addition, he would not get as bored as Gell. Or if he did, he would not complain.

Gell felt he should discover as much about humans as he could. They had transferred a huge amount of history to him; he thought it was everything they had brought. Certainly, it was far more than he could radio.

At the same time Gell was planning to go to Melior, he sent an interstellar vessel back to Xi Bootis. The space ship was also built by tree tortoise assemblers. Like him, the one tree tortoise who crewed the ship would slow during the trip.

Gell thought the humans were right: most of the time, no one needed an awake, conscious entity. Once, he had slowed his internal processes so much he could see a nearby star move. That was fun. It was a test procedure. He described the results in his first communication home, which was not until he could assemble a large enough transmitter. Mostly, though, he had not slowed his processes sufficiently. He had to wait to see any change. Even though external time passed vastly faster for him than for a normal tree tortoise, it was not fast enough.

Non-conscious but smart computers kept a good watch. They could bring a conscious entity to speed in a very short time regardless whether that entity was stopped or slowed. Nonetheless, Gell was not going to go against procedure, not yet.

Zill was the name of the tree tortoise going back home. Gell remembered that in his organic body Zill been big, a lunk. But he was smart. Moreover, he talked about returning to the Ulterian system after a short

time. He would return after the first tree tortoises went down to this system's Jovian, but not that long after.

They could certainly feed the small number of people who could travel as slowed computers, presuming they could be transferred to organic bodies. However, if Zill carried a large number as dead data packets, could they be fed? Gell was not sure, although it would be straightforward to find out. It did not occur to him that food could be duplicated, like solar energy collectors or anything else, and was not an issue.

Many of the other tree tortoise interstellar travelers presumed either that the humans had already showed how to impress otherwise blank bodies with tree tortoise minds that came in data packets or that the tree tortoises at home had figured that out. They were wrong.

However, Tuppak said impressing was possible. It was not as easy as impressing human minds on human blank bodies. It was easier, he said, to go the other way, to impress organic tree tortoise minds onto computers. "That is a difference in biology," he said. "Once we have figured everything out, it will be simple, but until then we must investigate."

Tuppak shrugged in a human movement. "On one side," he spoke the phrase like a tree tortoise; he did not say 'on the one hand' like a human, "we have done it before with humans; that will make it quicker. On the other side, we lack researchers in this system, whether human or tree tortoise. The answer will take hard work plus genius. Duplication could provide the entities for hard work and genius, but I do not want to duplicate and you don't. I don't think Moel does, either. My hunch is that your people at home will be best. They have the entities. The trade-off is time. We have to wait a half dozen of your original years just for the radio transmissions to crawl back and forth."

He did not know that the aliens had not brought the data for a tree tortoise body to the system; they did not know that impressing would be possible. They had not even brought the equivalent of tree tortoise zygotes. The tree tortoise colonists expected to live on the new planet but stay in robot bodies, at least for the beginning.

Although power, antennas, and compression made interplanetary bandwidth high enough, they could not be made comfortably big enough for rapid interstellar communication, even with assemblers. The beam spread as it traveled. A transmission would take longer than carrying the data. However, once a physical instance reached a destination, other bodies could be radioed by sending data that reflected only differences. That is what humans did.

Djem and Leestel wanted to return to Melior, too. Perhaps, Gell thought, they intended to keep an eye on him. Not that he minded; he wanted the humans to report that he, and by implication other tree

tortoises, were good. Djem and Leestel would slow down during the voyage. Indeed, Gell realized, they would stop entirely for the travel time. It would take five dozen terrestrial years. Since the human brains would be reborn into inorganic substrates, they would become alert immediately. Unlike organics, their inorganic brains did not have to let their nerves connect properly.

They hoped to visit Nebber after it became a living Jovian. For that, their bodies would stay in orbit or perhaps on the surface of Ulterius itself. They would shift to robot bodies in Nebber's atmosphere. Later, they would return their memories by radio. That way, nothing material had to be lifted in the Jovian gravitational field. However, it would not be worth visiting for a gross of terrestrial years. So, like Gell, Djem and Leestel planned to go to Melior, spend time there, and return to Ulterius.

For the interstellar voyage, the assemblers made several data packets of Djem and Leestel. After all, each dead data packet was the size of a bacterium. Indeed, all the critical information was replicated. That provided a very high probability that at least one instance would come through. Over all, the chance was good that when the space ship reached Melior that the right data would be there; otherwise good data would continue unused.

The interstellar space ship carried all the data on Ulterius, the human planet, which was not that much; Earthly human history just in case, which was quite a bit; and the tree tortoise data, which was more than could be radioed.

Gell backed up too. He was sent as dead data packets, but no one expected to use any. In his computer, he was big enough so that a cosmic ray would not cause much damage. Nonetheless, Gell was bemused.

Chapter 17

"We have trouble on Earth," said Aglar, "led by Gimmelwaet, Lentor, and Zudduk."

"They sound like a Victorian law firm," said Telren. Tuppak laughed. Djaeds looked puzzled. Aglar explained, "Law firms carried the names of their partners. Because of several novels, people began to presume that English lawyers in the Victorian Age not only were peculiar people but had strange names."

"I see," said Djaeds. Aglar went on. "It was not true that they had strange names, were peculiar, or that they formed wicked law firms, except occasionally, but it was a wonderful literary presumption!"

He returned to the topic. "In any event, Gimmelwaet, Lentor, and Zudduk want to stop the aliens' expansion. They are fearful lest they take over the galaxy."

"Fear is powerful. It is relatively easy to demonify a distant, potentially dangerous entity," said Djaeds. "I should know; I did it myself on Melior."

"You were once head of the Earth Beware party," said Telren.

"Yes, that was directed against Earth, against other humans," said Djaeds. "It turned out the fear was unfounded."

"You and Gellor kept the party going for years and years. It was not until after Djem killed Gellor and after you came here that you decided that Earth is safe," said Aglar.

"Earth's threat is low," said Djaeds. "Regarding the aliens, as Leestel said, which persuaded me, they will learn willy-nilly. They already have assemblers. That means we cannot destroy them. We can only become more resilient and try to win their friendship. That is for us on Melior and Ulterius. It is exactly the same on Earth.

"Who cares about threats when the threateners don't have dangerous weapons?" Djaeds posed a rhetorical question. "In this case, we can survive well so long as they don't have access."

"Problems come when they do." Djaeds was firm. "We don't know how resilient the aliens are. Since they may well have assemblers hidden is the outskirts of their solar system, like we do, they could damage us if any human damaged them ... yes, if attacked, the aliens should first find out who damaged them specifically and tailor their response accordingly, but the survivors might not ..."

Telren was breathing hard. "Maybe that is the answer to Fermi's question. 'Where are they?' Maybe every intelligent species has ended up meeting others with assemblers and they have killed each other off."

Djaeds asked what is Fermi's question? Aglar obliged.

"Fermi lived a very long time ago," he said, "before humans went off their planet, when electronic computers were in their infancy. He was a leading physicist. At lunch one day, the story goes, he was told about possible aliens. He thought for a short time and realized that even at a twelfth lightspeed, even at a twelfth of a twelfth, taking into account pauses and so on, any species capable of interstellar travel could settle the whole galaxy in rather less than one of its turnings. In geological terms, the duration is short even if it is a huge number of human lifetimes. So he said, 'If we are not the first in this galaxy, we probably would not exist.'

"As for an answer to the question, David Brin, another physicist and a writer, talked about the 'Great Silence'. The usual possible causes are twofold, internal and external.

"An internal cause does not require an interstellar, alien species. When you have used up enough resources but not yet invented fast assemblers, those that follow can't afford to invent. Every species uses up resources; the technologically capable do so quicker . . ."

"What about renewable resources," asked Djaeds.

"Some renewable resources, such as certain aquifers, take many more generations to refill than to empty. From the point of view of a technologically capable species, they are not renewable. And other resources, like coal or magnetite, come in fixed quantities. They are finite."

Aglar went on. "An external cause requires that someone be paranoid or xenophobic. With power, such an entity can weaken its neighbors. It does not matter whether the entity is one individual, many individuals cooperating, or whether it represents its whole species. Alternatively, entities otherwise well intended may launch interstellar robots that mutate to become deadly.

"Remember, not everyone has to die. Instead, everything must become too expensive. We forget that interstellar travel takes an enormous amount of technology. We do not pay because von Neumann machines manufacture and copy everything, including the data. That is what assemblers are. Self-replicating machines are combinations of assembler and recorder. When we design them, their extra production is good for us.

"But as Tuppak will tell you, and Filgard if he were here, the first instances took generations. Success did not merely depend on technological capabilities and intellectual ingenuity, it depended on funding. Smart and properly educated people were hard enough to find; getting funding was difficult."

Aglar did not talk about cultural constraints, another issue. Because change hurt them or might hurt, the powerful often saw any new action, even one that helped most people, as a change for the worse. Also, he

did not point out that a universe could and probably did suffer both internal and external hindrances.

Tuppak cocked his head. “When it does not slow, an incoming space ship hits at one-quarter the speed-of-light. Because of their size, space ships’ sensors lack resolution. They can correct their flight enough to hit a Jovian planet, but they won’t be able to discover a city or tree. However, multiple space ships can send information to each other that enables them to increase their resolution. They can hit close enough to kill many.”

“Gamma rays can vaporize incoming space ships,” said Djaeds. “Assemblers in the home system can build radars to see anything incoming. The space ships cannot move sideways enough to avoid the gamma rays.”

“Stealthed space ships,” said Tuppak, “cannot be seen or will be seen too late.

“To handle stealth, the sending side must transmit a warning by radio. Since the tree tortoises’ home planet is more than a dozen and a half light years from Earth, Earth has five dozen years to discover what happened and transmit the warning. That should be enough time. Other than that, we have mutually assured destruction. Hidden AI assemblers retaliate.”

He smiled. “Moreover, AIs can revive those backed up. That would not help Earth but would help us Melians.”

Djaeds nodded. “And we won’t know when the aliens started backing up. They may be doing that already. After all, they must have learned about back ups two and a half dozen terrestrial years ago.”

“Yes,” said Tuppak, “it is easy to handle anything already in an inorganic substrate, like Gell or Moel. It is harder to grow an organic body quickly, hard to ensure it grows as a blank, and hard to impress outside data on it eventually. But it can be done.”

Chapter 18

Gell's interstellar space ship slowed by running into the ionized particles pushed off the Melian star. Much more slowly in terms of interstellar speeds, it came to Melior itself.

There, as instructed, it adopted the same orbit and came very close to a big wheeled space station. Once in the appropriate orbit, long metallic manipulators grabbed it and took it into a non-rotating part of the space station.

The humans provided Gell's space ship with enough matter for his assemblers to build radio transceivers for signalling Xi Bootis and the Ulterius star and for building satellites around Melior to relay from the surface to the big transceivers.

At the same time, a tree tortoise assembler made another robot. The new robot could not travel interstellar, but it had sensors and manipulators. Moreover, it had the same shape and the same connections as the very first in which Gell approached the humans. Gell transferred his self to it and moved through airlocks into a pressurized part of the station, not that Gell thought there was much pressure. Still, the pressure and the gasses it compressed enabled a human body to live.

In the pressurized compartment, hands from the space station put Gell as a robot gently into an entry in the back of the head of a force-grown human body.

It was not an inorganic robot body. The AIs and organic humans who discussed the matter decided that Gell would get a better sense of what humans were like by living in an organic body.

Other humans would behave differently to anyone in an inorganic robot body. By law, although not by technology, humanoid, inorganic robot bodies diverged from humanoid, organic robot bodies. That was to prevent confusion. Children were supposed to learn that a robot is a non-sentient machine that may be able to talk but does not look human except in the most general way. Children hardly ever met AIs or humans who wore robotic bodies and until Gell came, no human on Melior had met an alien.

In addition, inorganic robot bodies had more capabilities than standard human bodies. They were always stronger. An organic human body, even one controlled by an alien, had the normal strength of a human and looked like one. Until discovering otherwise, people on Melior would think Gell a human.

Djem and Leestel were transformed from dead data packets into two humans that looked like they did on Ulterius, except they were in organic rather than inorganic bodies. The minds of both entered inorganic substrates.

Djem nodded approval. “This is where I first came awake,” he said, speaking of the space station. “When that happened, I did not know anything. I was born completely organic, which at the time was better for me. I worried more than I should have. Now, I prefer coming alert immediately, which is the value of an inorganic substrate. But a completely organic mind threatens less.”

He reminisced. “I remember the first time. Djammae Gammae helped me reconnect my nerves. In addition, she guided me in ways I might have resisted otherwise. She came down to the surface of Melior and continued working with me.”

Gell wondered what kind of learning he might have missed. He spoke and Djem said, “Leestel and I will try to help you as much as we can. Like my coming here, the goal is understanding. That leaves options open. Although one species or another may decide to damage the other, peace makes more sense, and I am not saying that simply because I am another diplomat!

“As for the space station, it is run by an AI called Airlent Irtak. I am sure you will meet him.”

Gell did. Airlent offered him an intelligent but non-sentient robot that would combine the duties of guard and helper. “We don’t expect you to need a guard, but a helper is important. You can ask him questions. The robot will report to security what you are doing. Being an alien, you cannot avoid spying, so you might as well get a good helper out of it.”

Djem agreed. “There are many advantages to having a helper. Yes, you are going to be spied on. The advantage of this place rather than Earth is that here the government and the courts are better.” Djem could speak with knowledge; he had been on both planets.

“Here on Melior,” he said, “crooks, cops, and powerful politicians cannot get away with spying for their own advantage. The customs and the law are against it. On Earth they spy, even though the law is against it. Customs and institutions permit spying.” Djem did not say anything about Airlent, who had spied but gave a warning when it looked as if Djem would be murdered. Airlent had not been doing it for his own immediate advantage and the warning uncovered him. He had been tried, convicted, and pardoned.

Gell, Djem, Leestel, and others went to the surface of Melior in an aerospace-plane exactly like the one by Ulterius. Gell felt almost normal. He was becoming more and more accustomed to a humanoid body.

It was not like his original body at all. Humans walked on a solid surface in an atmosphere in which none could float. They looked out of eyes with a narrower color range. Moreover, they walked in a direction a quarter circle from their bodies’ long length.

On and near Melior, the architects designed everything for humans, including the space station, the terminal building at the airport, and the rest of the buildings on Melior.

Eltis met him when he landed. "Welcome to Melior," she said. The event was not quite as formal as it might have been and Djem felt he could interrupt. He said that Eltis had not met him. "Kulray Pakkard met me." Eltis looked at him. "You were just another human, albeit the first from Earth, an Envoy. I remember recognizing your embassy on behalf of the government and making a speech on the undesirability of interstellar war."

She turned to Gell. "You, on the other hand, are an alien. I know, you did not plan to contact us. You did not plan to become an Envoy. You expected to be a competent spaceman, making the first interstellar voyage. You went to a dead planet, and expected to help your people bioform and settle on it. But here we are, in what to you is a third system. This one does not have your kind of Jovian." She looked cheerful. "Now you are an Envoy, regardless of your intent. Doubtless we will have political trouble; I am sure we will overcome it. Enjoy your stay."

Then she focused on a concern that she knew Gell felt. "Rill and your home government," said Eltis, "will hear from us that you arrived safely before hearing from you. We have already sent that signal. But you and your colleagues will trust your own devices more than ours. That is why we are providing the matter to build them." Gell nodded. Starting their construction had been his first action. "We will give you a human-built building like we gave Djem. That will be your embassy."

Gell knew it was not the building itself that was valuable, but its location. Was it central or not? Like tree tortoises, humans could produce material objects, but they could not avoid the immaterial desire for status. And worse than the vast majority of tree tortoises, their statuses were not determined by the tree they were born to — humans did not have that kind of tree. Status was not decided by a father's occupation, either, or by genetic relation, by clan, but by themselves.

"We in the human government will provide a short, official 'recognition' of your status — that is the word we are going to use since you do not have any papers. Following the Recognition ceremony, we will have a reception, just like we had for Djem. You can use the reception to meet a good many centrally ranked Melians."

Gell nodded. "Yes," he said, "I am not much for official events, and I won't look normal, like a tree tortoise, but I know how important this is to you." He did not speak of tree tortoises who went between different factions. They enjoyed or suffered the same kind of ceremony. Nor did he say how happy he would be to meet humans.

A surface vehicle carried him from the terminal building to his embassy. For whatever reason, the ground car was called 'an embassy limousine.' Gell was separated from Djem and Leestel, who went in their own vehicle to Djem's embassy building. The other car looked exactly like his.

The helper robot that Airlent had given Gell was the only other somewhat human appearing entity in Gell's vehicle. He said to Gell, "Melior and its surrounding vacuum are filled with radio signals you can intercept and decode. You have not done that yet. I see, you don't have a thick radio environment on your home planet, or at least, not in any records you have provided."

The robot kept talking, "Your home planet is more like our home planet, Earth, than like Melior. To have transceivers built into your body, you have to be reborn, be a sophisticated robot, or else have them grafted on. Unlike we on Melior, most Earth people and most tree tortoises have not been reborn, have not been put into robot bodies, and have not received transceivers in any other way.

"My point is that you can readily receive radio transmissions of the stories about you. You will understand us humans better when you survey them both as ambassador and as anthropologist. Here is what you do to receive radio . . ."

Gell followed instructions and promptly saw himself, in a human body, being met. From Ulterius, he knew that humans distributed information by radio, but Melior distributed much more. Gell decided that was due to Melior's higher population.

A news story about him being met showed pictures of him and Eltis. It carried the remarks made by Eltis, and explained that he really did not look human, but more like a fish, that he asked for his species to be called 'tree tortoises,' and that his kind mostly lived in a different ecology in an atmosphere more than five gross as dense as Melior's.

The news story showed moving images of a tree tortoise; it looked like an Earthly fish. The images were of a diplomat from one of the factions, swimming into the main cavern on the central tree. The camera had been high up. You could see all six appendages on the tree tortoise. You could see that each appendage had four lobes. You could see the eye stalks, and you could see the streamlined, skin-hugging clothes that were customary. The background was not cluttered. That may have been why human editors picked it. Anyone could see the diplomat. Humans would not determine the location, but Gell could. He had been there.

The story also explained that among tree tortoises, shorter names indicated higher status. It said that Gell and his colleagues had been given one syllable names before they left home.

The two embassy vehicles stayed close together, with Gell's in front. Gell thought that two were a waste. But then, he thought that most show was a waste.

Finally, the two cars went different ways. The first went into one building, the other went to a building next door. That is how Gell found that his embassy had been built next to Djem's. That was a good location. Gell knew he could have discovered the location by asking internally to see a map but he had not perceived how concerned he was.

Like Djem's, Gell's building was surrounded by a private park. Gell saw more open space beyond his edge. The land had been set aside for more embassies. Although the public could walk in that part of the park for grosses of years, they would not be able to use it forever. Gell laughed to himself. It did not matter whether anyone imagined his years or terrestrial years. In the long term, the park was temporary.

Gell discovered that humans used two different numerical bases. On Earth, they continued to use a numerical system derived from their ten fingers. They did not look at a hand with its fingers curled, as they did with base twelve. When a human hand had its fingers curled, the tips and those knuckles closest to those tips added to twelve. They divided properly into fours and threes.

Gell thought base ten foolish. Nonetheless, humans did manage to go interstellar with that base, so it could not be all that foolish. He much preferred the Melian base twelve. It was half Gell's native base and not bad at all.

It finally occurred to Gell that humans may have adapted base ten so they could easily show finger counts to each other. Humans had to use words to convey base twelve numbers, which is to say, they had to make sound. Sometimes silence was better.

Then Gell realized that some human numerical systems suggested a base that was twice the number of fingers. Gell could see signaling with hands, but not with feet. Humans often stood on their feet. They were not like tree tortoises who floated. He could imagine barefoot humans counting their own toes. They could learn numbers that way, along with addition and subtraction. It would be like looking at a curled hand. He could not imagine humans waving their feet for others to see. He puzzled.

Gell liked floating underwater. But even with fins on his feet, a kind of shoe the humans had invented, he did not enjoy swimming. For one, he only had four appendages; he had no central fins. It took effort to stay in one place. At home, a tree tortoise had a very different experience. All in all, he decided, it was better to stay away from the water.

Presuming you lived on a solid and could ignore the support of air because it had a low density, presuming you had two legs, walked upright at right angles to your long axis, had eyes that aimed where you walked . . . the houses looked normal.

They did not look like Gell's. His were caverns in a tree. Tree tortoises swam into rooms. Unlike the humans, who had them everywhere, tree tortoises never needed paths or roads.

During the day, Gell mostly studied the humans. He wore a human, organic body and, in effect, was disguised. Unless he told people or unless they knew him, people presumed he was human. Occasionally, someone recognized him from news; he was, after all, famous. But that happened so seldom he could take anonymous walks. He started a new habit; each day, he walked to and in a different part of the city. He listened to people; even with his human senses, he was able to hear a vast amount. The people he met by chance, mostly at restaurants and bars, were happy to talk.

Although the humans lived in a vastly different environment, their hopes, concerns, and dreams were not so different from the tree tortoises he left behind: all wanted to live a meaningful life, to avoid falling behind peers, and to hear about strangers. The last told Gell that he himself was a dream personified.

Before the end of each conversation, he took care to tell each of his interlocutors who he was. He said he was doing as best he could to study humans without influencing his data set. Everyone understood. Several humans said, "At the same time, we are studying you." The humans he met were better than tree tortoises at home, but perhaps that was because they were a self-selected subset. He met almost none who had been born on Melior.

Some nights, he looked at the stars. One evening, Djem and Leestel came upon Gell between the two embassy buildings. "It is strange to be able to see stars down to the horizon," said Gell. "Because of our thick air, we can see them only part way down the sky. Our sun is the only star that we can see go hide behind our planet, 'set' is the old term. Can we see Xi Bootis from here?"

"No," said Djem. "We cannot see it. Incidentally, both the Ulterius system and the Solar system are in the same direction as Xi Bootis, more or less. Maybe less is right, since the angle between Sol and Ulterius is a bit more than a third of the way across the sky as you see it. However, the angle between Xi Bootis and Ulterius is less than half that." Leestel did not say anything.

"Leaving aside the angles," said Djem, "all those stars are dim. They are ordinary and distant. They are not as bright as bigger, faster burning stars. However, since the Melians do not like waste, we would be able to see them in a capital city, dim as they are. Nonetheless, you

would have a better view in your original body than you do in a human one. The other has better night vision than we humans."

"Yes," said Gell, "we need it. Better vision is helpful in rooms. They are, or were originally, cavities in trees and are usually lit from only one side. Even during a bright day, they were and are dim.

"Naturally, people always explore deeper. Those caves are safer and more central. Moreover, you might find treasure! At least, children think that. Trees sort and sequester metals from the atmosphere; as dust or smaller particles, they are poison. As lumps they aren't. Occasionally, a cavern will hold a fair amount. Or it will hold the dead body and belongings of an old person. Rather than die and have their bodies protected in a special room, dying tree tortoises sometimes act like children, head centrally towards what they think is safety, and are not caught."

"So young tree tortoises head towards a center. That has many implications," said Djem.

"Yes," said Gell, "It has been discussed frequently. Once adults got over thinking that people on other trees were enemies, not part of the same group, they could think that another tree was more central than theirs — and attractive because it was more central.

"Returning to caverns," said Gell, ". . . nowadays, of course, every cave that you can go to readily has been explored. Children do not believe that, but it's true. Only archaeologists go deep enough to find treasure. What they do find is seldom enough to pay for itself. They mostly find metal since they are investigating beyond what even a dedicated, but dying tree tortoise might do." He cocked his head. "I don't think you should call them archaeologists any more since they are not looking for old tree tortoise items; but that is what they are called.

"Some claim we adopted fire in order to carry torches to light our way into caverns. That might be true. Lightning could start a fire outside and an early tree tortoise might carry a burning branch inside. That would light up the place. Unlike some of our relatives, we never developed internal sources of light such as that produced by your deep sea fishes. We did not develop echolocation, either. We are not like your bats. But then, those species, I mean our Jovian species, never made use of fire. The echolocators became pets." Gell was a little sour at the last remark, Djem did not understand why, but he set the mystery aside for the moment.

"Among humans," said Djem, "current architects suggest that natural light come into each big room from at least two sides. Interestingly, people prefer natural light over artificial light. They prefer light from the Melior sun, even though its light is a bit redder than the light from Earth's sun, not that anyone without a spectroscope could see. There was a period when electric lighting became cheap, which enabled you to

put rooms inside others. At that time buildings on Earth depended on it rather than on natural light. When you bury rooms, design is easier and buildings are cheaper."

Gell responded. "Our houses are not like that. Even cities consist of caverns dug out from or added to the sides of trees. Most inhabited rooms have a window that goes straight outside.

"Differences in pressure between the inside of a tree and its outside transform into air movement. Deeper and larger caverns lead to more movement. That is how fresh air enters houses; all have windows that let air in and out. Air can enter and leave single rooms, too, but not as well. All house rooms possess open windows."

Gell finally made a new comparison: tortoises' trees breath like humans although they did not need to expand and contract lungs. He had not made that comparison before. Initially, he had only learned about tree tortoise lungs and those of similar animals. The air for those lungs passed through, incoming air into holes just after eye and ear stalks, exiting air from holes farther back, each in front of a middle fin. Unlike humans, who had just one entry for both lungs, each lung had its own.

"In the morning in daylight, air in a cavern is cooler and denser than the air outside. As it warms, it expands and leaves the tree. During the evening, after sunset, the air cools and contracts. New air flows in. Hah! I have gained knowledge about the temperate zones of Terra: air movements are delayed during a day and a night like summer and winter are delayed during a year."

"Earth is a good insulator," said Djem, "so is air, even dense air. What transfers the heat?"

"Plants, more specifically, their roots," said Gell. "Don't ask me how. I learned what goes on but never thought of it before. You can get the information as easily as me." Djem did not ask and Gell returned to the main topic.

"For us, a window is the same as a door. A chain of rooms goes along the flank of a hill, not into it. Each room has a window. In houses, you almost always have to go through one room to get to another, although rooms are usually separated by short tunnels which in turn are illuminated by outside light coming through narrow passages that only children can squeeze through.

"Where are your windows?" asked Djem.

"Often, opposite the floor," said Gell, ". . . that is a good point; you would call them skylights, except we look through them. When houses are in steep hills, windows are on the side. A floor is always towards the center of the planet; that's the direction that gravity pulls. Windows open to the atmosphere. In some houses, they are to the side of the floor; in other houses, they are opposite.

"For security in cities, windows have grids or bars over them. They swing shut. Except no one carries a key to open them. Away from cities, in country districts on big trees or on remote trees, all entries are left open."

"That is like us humans on Earth," said Djem. "Here on Melior we use fast assemblers, which make a difference. No one here worries about material gains or loses; they do not lock doors." Leestel interjected. "A few do," she said, "but I agree with you that most don't." Djem ignored the interruption. "Instead," he said, "most people worry about that which cannot be stolen but can be hurt, like reputation and status."

"What about certificates?" Gell asked. "They are needed when strangers interact. Ah, never mind. I see the answer. Robots do not forget. They distinguish individuals. They communicate. So you don't need a certificate to tell a stranger. Robots will complain if you don't tell the truth, so you might as well tell it."

"That is why so many humans were worried by computers," said Djem. "Robots are run by computers which have electronic memories. A skilled and trained person can modify information, even when it is encrypted and sits in a multitude of devices. You can pretend to be better than you are; you can attack people you don't like. You merely have to be a crook or a corrupt politician or have connections to one or the other. To prevent such modification, besides appropriate technology, a society needs the right social institutions and the right expectations. The Melians have them, so they dare go further than Earth."

"We tree tortoises change so slowly that old abuses appear just. Those that children did not come to accept vanished generations ago. Also, as far as I know, no one wrote about data modification when computers were introduced. I never read anything." He shook his head.

It was starting to cool; Djem suggested to Gell that they go inside his embassy and listen to music. "We are neighbors, after all, the only Envoys on this planet." Leestel continued not to say anything.

"I can hear what you call frogs and birds," said Gell. "This city is remarkably quiet."

"In the old days, cities were not like that. On Earth, big ones are still not like that. Quiet electric motors help. So does quiet mass transit. In early days, the drivers of private, inanimate vehicles liked to announce themselves; there were not many and their engines were not intrinsically quiet. Before that, the outsides of cart wheels often were metal. Metal wore better and rubber tires or their equivalent had not been invented. Metal tires clattered against cobbles."

Djem thought for a moment. "Some noise is a consequence of technology, but some is not. You, or rather an engineer or architect, can misdesign vehicles to be noisy."

"We shifted from steam to electricity without pulsed internal combustion. I learned you adopted pulsed internal combustion engines in one of your histories. Before we had steam, animals provided energy. So intrinsically our vehicles were always reasonably quiet," said Gell. "Our vehicles have always been like your submarines except they moved in what we think of as air. In the old days, we streamlined them, as of course we still do. They did not produce noise then and they still don't.

"Your vehicles never needed a pulsed internal combustion energy source."

"Internal combustion engines start quicker than steam engines," said Djem.

"That is only with poor design. On Earth, you had quick starting steam engines before the Model T Ford," said Gell. "I have looked at your technological history.

"But our cities were noisy and still are. The sources are other tree tortoises and pets."

"Humans and dogs make noise," said Djem, "humans shout, dogs bark. Nonetheless, in many parts of them at night, cities are quiet."

"Our pets depend on echolocation which we can hear," said Gell. "The frequency prevents a good resolution, thorns cannot be discovered, but it is good enough. We not only can hear our own pets, we can hear our neighbors' pets and the pets of our neighbors' neighbors. These pets sleep at night. Unfortunately, they do not stop making noise. It tells them where they are. I find that noise a bother; to me, it is a high scream. Other tree tortoises learn to ignore it." That explained to Djem why Gell frowned at pets!

"Music is intended sound," said Djem. "Humans make it and listen. Now that I look, I see that you tree tortoises do, too."

"Yes," said Gell, "I have listened to human music. It does not come across the same way as ours, although your and our frequency ranges cover about the same number of octaves. Like you, our music depends on notes. Interestingly, music in a major tradition of yours has fewer notes on a scale than we do; you have eight or a dozen; we have nearly three dozen." Djem raised his eyebrows.

"Just as you humans, we move strings back and forth; we vibrate air in tubes. We are talking about our atmosphere, which has a decent density, about the same as your water. I don't think that matters though. When the first attempts were made to codify our scales, we found that octaves divided much more finely that you. Incidentally, our experiments depended on tubes, not strings like your Pythagoras. (Like our Deb, your Pythagoras may be mythological. Or perhaps either or both are partly real and partly unreal. It does not matter. Deb is similar to your Pythagoras: both are said to be great mathematicians and experimenters!)

"To me, your human music sounds weird, but not bad."

"Strangely enough," said Djem, "I have not listened to tree tortoise music. It never occurred to me. I am not a musician and do not talk about music. Perhaps I should become a musician and talk about it more, but I do not think of it."

"You do other things," said Gell. "Music can be a pleasure or it can be forgot. Let's eat, too."

"What?" asked Djem.

"I found that as a human," said Gell, "I enjoy human food even more than I expected. As an organic tree tortoise, I ate organic food, but paid little attention. I pay more attention now. Indeed, I enjoy eating so much I have toyed with the idea of gluttony, but my temperance has overcame my desire."

Djem was startled at the thought that someone might toy with gluttony, but said nothing. Instead he asked, "What was it like when you were a pure robot?"

"As entirely a robot," Gell laughed, "not a partial one as you and I are now, I gained electricity from other sources. They were not tasty. When I went long enough without electricity, I felt hunger; obviously, the emotion drives us to eat. Doubtless all creatures that have a large enough mind, Earthly or otherwise, feel hunger when they lack food. Some foods provide better energy than others, so you expect them to taste better. Organic beings need more than energy, so other substances have a taste, too, like salt. Salt tastes good when you don't have enough.

"I find it strange that as a robot, electricity lacked taste. It did not taste bad; it did not taste good; it did not have any taste. But I had to get more every so often, or more helium three for my fusion reactors. As I said, without enough electricity, I would feel hungry. I think there is a problem with my programming. As a robot, when I am hungry, a clean electric current should taste delicious, that is to say, it should trigger the same emotions as eating a good meal does when I am in an organic body."

"We will feed you," said Djem. They went inside.

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Gell, Djem, and Leestel connected with Taffod and his duplicate Tindark. Djem and Leestel enjoyed them no end. Gell thought the experience strange, since he had already met another duplicate, Telren.

Telren had left Melior and gone to Tegmar. There he had been reborn into a babbo body with six appendages, not four, like the other humans or like his duplicates. Telren had persuaded Tuppak Nassik to adopt a babbo body form on Ulterius. Torkun, yet another duplicate, was the Melian Envoy to Earth.

Gell asked why there were so many Taffods. "I thought humans were against duplicates," he said. Taffod responded, nodding his head. "Most are. And the society supports laws against making duplicates, except in certain cases, which are called 'national treasures.' That is what I am, a 'national treasure.'" Gell could hear the change in tone that indicated he put quotation marks around the words.

"I became a national treasure," — this time Taffod did not use quotes, but spoke normally — "because people liked my reporting. My duplicates have the same ability and knowledge. More recently, I ran out of adventures and have duplicated in hopes I be the person who goes elsewhere or that I would die forever, but I haven't. Well, if you are duplicating, there has to be someone who stays behind. That is this consciousness.

"I am getting bored. So is Tindark. Telren went to Ulterius because he was no longer finding the new or strange on Tegmar. (Torkun did not have a choice. He first woke by Earth.) Tindark and I have lived as much as we can on Melior. We have been thinking of becoming interstellar explorers, but are glad we didn't. Not knowing about you, we would have gone in the opposite direction.

"Reversion, the proposal that you give up everything external when you are reborn, that may help. And you will help." Gell raised an eyebrow. He was learning all the ways these humans had to communicate. "You, meaning you tree tortoises, are different from us humans. You are different physically but not mentally. Just as we will be interesting and comprehensible to you, you will be interesting and comprehensible to us.

"No individual wants personally to die. Or few do. With inorganic minds, rebirth is simple and safe. Rebirth into organic minds is becoming safer and safer. Most humans insist their minds remain organic.

"Reversion forces changes and gives a chance to the next generation. We just heard of the notion. No one had thought of it before, although now that I think, it is obvious. When there are too many in the next generation, we need to put reborn people into a different activity or at least cause them to think again. The goal is to shake them. Earth had enough people. The 'younger generation' made reversion politically acceptable and possible. You tree tortoises are going to make bearable our 'indefinite longevity.'

"You have a longer history than we humans. However, I don't think you have had a much experience with or have thought about indefinite longevity as much as we. As far as I can determine, reversion will succeed for you as well as for us. The discovery of a technological, interesting alien species helps. So I am glad you are here."

Tindark said, "We Melians are different from those left on Earth. For one, we have always used von Neumann machines. Initially, Djem

did not know about assemblers, even though he was a high level civil servant." Djem nodded.

A flock of geese flew over the city. Taffod remarked that these geese were genetically engineered to fly closer to the equator than they would otherwise. "We are in a comfortable place, but not all the Earthly animals we like would come this close to the equator. That is why we change them."

Gell thought about them a moment, or perhaps he remembered his original Jovian. "How do you prevent there being too many?" he asked.

Taffod knew. "Non-sentient robots use cross bows to shoot geese. They seldom miss; geese tend to be predictable. In any case, the robots know where the bolts will fall if they miss, so they shoot so as to avoid hurting anyone. They use cross bows because they are quiet. I appreciate that. The robots are strong enough to pull them. Many Melians don't like killing geese. However, when you are managing a planet you don't want to engineer a birthrate down too low lest the species be unable to handle variations. That does not make sense ecologically.

"We could make new geese if the species vanished, but if we presumed to do that regularly, we would end up a quite different society. We would become excessively artificial. No one wants that. No one minds the degree of artificiality that currently exists, but no more! That is not rational, but that is the way it is." Gell nodded. Among tree tortoises, children accepted the world. Humans were the same.

Taffod continued. "So we must kill some geese. Extra geese must either be killed by us as a predator, by a non-human animal, or by robots. One advantage of a robot is that he is strong and accurate. A goose he chooses to kill dies quickly. A non-human animal often will take longer, as might a human. Another advantage is that a robot does not depend on geese for energy. Many of us who are organically based eat the killed geese."

"A third advantage is that the robot used is non-sentient," said Gell.

"Yes," said Taffod. "You understand perfectly." He nodded and grinned.

Tindark shifted the topic. "Von Neumann assemblers are important for us," he said. "They are not simply a way to build the generators needed to get off the planet, as seems to be the case among you."

Gell did not agree. "We do a great deal with assemblers," he said.

"Not as much as we do," said Tindark. "Among other things, assemblers reduce the crime rate. Melians do not steal material objects since fast assemblers can make them readily. Interpersonal crimes remain, those of violence."

"We don't have a high crime rate!" protested Gell.

"Neither do we, not any more. Partly crime's ending depends on abortion, whether or not the unwanted are born. Partly, on the amount of lead that children injest. Partly, its ending depends on catching crooks quickly, so deterrence acts. And partly, its ending depends on reason, so crooks can be reformed and others believe in the legitimacy of society," Tindark said.

"In addition, our population is small enough that we have little planetary impact. That is another kind of crime. Although sometimes particular people are responsible, usually individuals are not. So necessary law must be different."

Gell focused on the planetary change. "You bioformed this planet. The word you use is 'terraform,'" he said. "That had a huge impact."

"You are right," said Tindark. "Terraforming did have a big impact; but the only life that existed before was bacteria. No one cares about bacteria. Or hardly anyone. Tegmar had complex life and we let it be. That is why Telren has more legs than you or I. He got himself reborn as a Tegmar babbo! As for Melior, since the terraforming, none of us humans have had much impact on the ecology, whether organic or inorganic. That is good.

"So far, assemblers have produced all the resources we need and prevented group violence. We have not had any wars between factions.

"But assemblers cannot handle needs for attention, status, power, changes of policy, and the like. So we still have crimes like that of Gellor Thurnsby, who tried to murder Djem when he first came as an envoy from Earth."

Djem nodded slightly. Gell did not know the story. He vowed to himself he would find out, but not at the moment.

Taffod told Gell, "We are here because we escaped Earth. We left because we could see it was going downhill and we could do nothing. By 'going downhill,' I mean, 'going bad.' It's a metaphor that depends on our living on a rock. 'Up' is better."

"We have the same saying," said Gell. "not the same words, but the same meaning. We swim over hills. As we go down, pressure and heat rise. Going up is bad, too. We lose pressure and it gets cold. Children are born and raised towards the center of a tree. That place is safer. Tree tortoises speak of 'the center' metaphorically. The equivalent to saying 'going downhill' is saying 'going away from the center.' I understood what you meant. I did not mistake it for gaining gravitational energy, the way one of your cars gains speed by going down hill."

"I understand. In any case, we left," said Taffod again. "Earth was going bad. Many — not all — of the people ruling thought too short term for practicality with nature; they did fine with other people like them. Also, they did not support enough of the kinds of research and positive interactions that would have prevented many people from dying

before their time. To their credit, they did not discourage everything and they let us go. Unfortunately, even though we look like a lot, we are a very small minority."

"In other words," said Tindark, "the humans you know directly create a poor sample. You will remember them best. I have looked at studies of your psychology. It is not so different from ours. Like most humans, what you see and hear immediately has more impact than what you see and hear indirectly. That made sense in your past, since immediate dangers could kill you, just as sabertoothed tigers could kill humans. Even if he was telling you something foolish, one of your speakers, like one of ours, could not say anything that would prevent you from saving yourself, perhaps in order to die later. No one wants to die for a trivial reason. A speaker will deepen the bonds of a group. That will help you as it helped us."

"The word 'deepen' is another metaphor which I understand," said Gell. "However, among tree tortoises, to go deeper is bad. It is like your phrase, 'going downhill.' With the word 'deepen,' you do not mean 'going downhill.' You mean 'increase the strength of emotional bonds,' or something like that."

"Yes," said Tindark. "I keep forgetting you are not human."

"We tree tortoises are different among each other, just as you are," said Gell. "It looks to me that we have the same fundamental forms of perception as humans, even though our bodies, our eyes, the rest of our senses, and the atmosphere are so different."

"What do you mean, the same forms of perception?" asked Taffod.

"One perception, which everyone has, is whether others create measures of some sort. Another perception is whether others fit a situation of equality or specified difference. Another is whether another is more or less powerful than you; and finally whether another is inside or outside your group. Everyone can and does all these quickly. But some prefer one kind of perception over another.

"People, both tree tortoises and humans discover prices; that is what I mean by creating measures. They find how much money to exchange for either an apple or an orange. The money enables people to compare the otherwise incomparable.

"What do you mean, comparing the incomparable?" asked Taffod.

"That's the ability to perceive comparative worth," said Gell. "Consider Earthly 'apples and oranges.' In one sense, or rather in at least three, you cannot compare them since they are different. They don't taste the same; they don't look the same; they don't feel the same. They are like our fruits. But if you pick the right numeraire, say barley, you can offer more or less for an apple or an orange. Money simplifies the picking of a single numeraire. You don't have to carry barley with

you. Money does other things, too, but for this purpose, think only of simplification.

"A single numeraire simplifies making decisions. Unfortunately and more likely, the numeraire won't be money. It is not sufficiently complex. Values are traded off. They are compared."

"I like the taste of an apple sometimes, the taste of an orange at other times," said Taffod.

"Yes," said Gell, "and when oranges were more expensive than apples and you could afford one or the other but not both, you wanted more oranges than you purchased. Different desires, what you value, how much you have, were traded off."

"With assemblers, we don't seek material objects," said Taffod.

"That's right," said Gell, "but you still seek services, location, attention ... only some of which can be purchased with a simplifying numeraire.

"To return to perceptions: besides creating measures, people discover who has the right to vote, which is to say, who fits into a situation of equality when the votes are equal. They discover the difference between the crew and the captain of a ship, a social ordering with the captain having much more power. Finally, or perhaps I should say, initially, people discover whether a person is like them or not.

"Tree tortoises have the same perceptions as humans. Yes, the inputs are different. We see more colors than you and smell in a much denser gas; but we analyze information the same way as you. I think the 'how' is fundamental. We have different groups of tree tortoises as you have different groups of humans. I have read your history. It is considerably shorter than ours; we have not changed as quickly as you have, not since the invention of agriculture. That may be because we unified the whole planet early on.

"In addition, new rulers came from the best of a tree rather than from a single genetic sequence, as was the case with you mostly. So we had fewer stupid rulers. Well, many of your smaller countries had smart rulers, but they were overcome. We have had only one country for the longest time. It has been pretty smartly run."

"You are an Envoy," said Taffod, thinking that he might lie for his species.

"Yes, but not intentionally. Besides, you can look at the histories we have provided — you will not find many stupid rulers."

"We can check. I am sure someone will; he or she will love your history. It is entirely new."

"Our history and your history both have terrible events in them," said Gell. "I would not say that one is worse than another. Over all, they are both ghastly."

Taffod interrupted. “On the other hand, based on the histories that you have shown us that I have had a chance to read, I would say that tree tortoises have had more periods of grace than humans, more years of peace.”

Vertical lines appeared on his forehead as he thought. “The evidence suggests that peace is a side effect of a primary group that comes from trees, your kind of trees, big and floating. After a gross of generations, everyone knows his or her place, a perception whether another is more or less powerful.”

“That is true,” said Gell.

“Your eccentrics,” said Taffod, “that is, the tree tortoises you call eccentric, include three of the four groups you mentioned: those who prefer more than others to compare the otherwise incomparable, those who prefer to decide whether a person is like them, which is to say those who prefer Aristotelian logic over other kinds, and those who invent ethics.

“In your case, your mainstream consists of people who prefer to determine who is more or less socially powerful. Because they prefer that perception they do it often and have become skilled.”

Taffod waved his head back and forth. “The existence of both eccentric and mainstream tortoises fits your suggestion that humans and tree tortoises have the same perceptions. Proportionally speaking, however, you have fewer eccentrics than the proportions among humans.

“Indeed, we don’t call them eccentrics. Among humans, they form a majority. For you, they are a minority. Nonetheless, in absolute terms, your number is large. Every tree has eccentrics.

“In two groups of those you call eccentrics, people prefer truth to harmony, or what they think of as truth. The first group consists of people who create measures to compare the incomparable; the second consists of people who determine whether another is similar to them. A third group is different; it contains people who prefer harmony, ethicists. The fourth group are the majority among you and the largest group, although not a majority, among us.

“Recently,” Taffod continued, “you seem to have benefited from the size of your planet. It is larger than ours; it can handle more damage. Moreover, your central tree, the tree that rules, that is to say, the tortoises in that tree, unlike many human rulers, have learned to think over longer terms than humans. Perhaps that is because the tree itself lasts so long.”

“I won’t argue,” said Gell. “You have done so much in so little time. You invented writing and you invented interstellar travel; you have done all that.”

“You are saying that we are disadvantaged?” asked Tindark.

"Well," said Gell, raising his eyebrows.

Both Taffod and Tindark thought Gell was funny. They suspected he mainly remembered that his people unified the planet a very long time ago. Both Taffod and Tindark wondered whether the unification among tree tortoises was similar to the human unification of eastern China in the preindustrial period. In Europe before modern technology, forests, swamps, mountain ranges, and seas made it too expensive to conquer permanently the area of more than one traditional country. Only a sea power, as Rome became, could conquer more. That was not the case with eastern China. A land-based general could go around mountains. It was not easy, but not as difficult as in Europe.

"In any case," said Taffod, "I was trying to say that different groups have different purposes among both tree tortoises and humans. Some humans may act dangerously to you. And because individual humans have gained so much power, your whole planet is at risk."

Taffod and Tindark explained human government to Gell. He learned that Melians employed a social mechanism that conveyed to most people the legitimacy of a government that introduced non-traditional changes within a generation. Both thought it was good enough.

A small number of people actively investigated continuously and a large number paid attention once in a while. Depending on the investigations of the former, the latter judged whether a government acted well or badly. Accountability and transparency were key. No one could investigate without transparency. Judgement failed without accountability.

The people in the government included those who balanced individual needs with themselves and with other members of their community as well as with their ecologies: they prevented solipsim by dreaming up schemes to pull people out of themselves; they regulated interpersonal interactions by preventing murder, fraud, and other traditional crimes as well as by preventing war; and, they regulated relations to the ecology by preventing such entity-caused disasters as unwanted climate change and other long-term possibilities that could result from material wealth.

They did more than prevent. They discovered reality by funding research, they educated the young, they enabled the older to continue learning, and they took care of everyone. Individuals could live their own lives and sell safely to others as well as give.

Since nobody in a government could hide, they mostly acted well. They stayed and government was stable. It all worked well enough.

Moreover, such a government could introduce a change in less time than it took for one generation to die forever and another to replace it. With indefinite longevity, rapid change became more and more impor-

tant. A living generation of adults lasted. Reversion did no good. It did not end memories.

And, Gell thought, with the appearance of tree tortoises, humans did have to change their policies, if only to agree to share the resources of stellar systems that had both suitable Jovians and suitable small planets.

Gell respected the humans on Melior. He knew that in practice, the humans on Earth were less honorable. Their governments lacked transparency and accountability.

Tree tortoises at home changed very slowly, much more slowly than the humans. In the past, a government never had to make rapid changes that were not traditional. Forthcoming changes were devised generations in advance. Even in Gell's life so far, nothing dramatic had occurred politically except meeting the humans.

Few had been uploaded to inorganic substrates as he had. All who studied the matter knew that Gell and people like him could survive for a very long time. That longevity was ignored. Organic tree tortoises were unable to live long. Their preponderance made it almost reasonable to ignore the consequences of uploading a few into inorganic substrates. But soon, organic tree tortoises would be able to live a long time, too.

That meant reversion would become necessary: every three double-dozen terrestrial years, or maybe every four, those living longer would lose their old status and power. In a family, the younger would inherit; in a job, the younger would take over. However, older people would not lose their memories.

That was one government action that had to occur soon.

Gell had not thought about the consequences of industrial technology. That was an advantage of a very slowly changing social system: what you were born with worked throughout your life. Tree tortoises had possessed industrial technology longer than humans. His and human technology was now electronic. With it, the powerful could influence others and gather information about them remotely.

Humans had used their technology in ways that other humans disliked. Attention gatherers, advertisers they were called, had determined who sought what. Police and crooks had determined who did what.

Obviously no person was bothered by having his or her attention directed towards something wanted; but enough humans had memories in which the non-advertised parts of cultures seemed to vanish. People received misdirected advertisements. Police made mistakes. That irritated.

Gell had not thought about privacy, either. No one wanted information collected mistakenly or without understanding.

So transparency produced a built-in conflict with notions of privacy. Both governmental and non-governmental operations collected data that told others more than people wanted to make public. Only though law could such information be controlled.

Perhaps tree tortoises had developed correct laws generations ago and the laws had become customs. Gell hoped so. Contact with these aliens, humans, produced enough changes.

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Leestel asked Gell whether he wanted to meet her parents. "They are wonderful people. I am prejudiced, of course; I love them.

"From your point of view, they are good examples of ordinary Melians. They are not grand or special, as are most of the people you meet officially. They live on the edge of the city in a comfortable house, on a larger than normal plot of land. They like gardening and indulge the desire. The land does not come from the garden though.

"Originally, they had a much larger house. That is why the land is on the edge of the city rather than in the city. When assemblers built the city, architects considered population density. More land meant less of a city. Most people want city and people rather than house and space. They want to live closer together."

"I have a huge place in which only I live," said Gell.

"You are an ambassador. We think of you as different. The category is old, it was old on Earth before anyone left; nonetheless, it succeeds.

". . . my parents had the old house torn down, a smaller new one built, and used the extra space for more gardens. You cannot get away with doing that close in, not unless you want your gardens to be open to the public. That creates a different feel.

"Such gardens are good for other people in the city, but my parents are not like that. Where they are is just fine."

"I will visit," said Gell.

Leestel walked him to a cable car station. A four seat cable car waited. "I ordered it via radio," Leestel said. "Before I got a radio put in, I spoke to the microphones at the base of each tower. We never have to wait but we do have to walk to and from the towers. Cable cars are only above major streets. Eltis and her friends who started all this hated waiting and thought walking would be good for us. Both are true. I hate waiting and I agree that walking is good. Nonetheless, I am amazed. If you went to Earth, which I don't recommend, you would find cities with many ground vehicles, no cable cars, other types of transit, and lots of waiting."

"Almost all the time, I ride around in my 'limosine,'" said Gell. "I have not yet gone anywhere in a cable car."

"Mostly Envoys and freight ride in ground vehicles. So do fire fighting and other emergency equipment."

"I am not sure I am in the best of company," said Gell, "what with freight and fire engines the alternative."

Leestel giggled. "In Earth cities, toll zones keep out all those except the rich and, as you would expect, emergency vehicles, sales representatives, and their necessary freight. I don't know what they do about the disabled. As an Envoy, you would be rich. You would have a ground car, as you do here."

She had been awake on Melior long enough to read Torkun's account as the first Envoy from Melior to Earth — he had not arrived on Earth before she left Ulterius. He had a ground car. She had not had time to perceive his more complete sensory compositions.

As the cable car moved along, Gell took in the view of the city. It was mostly low. At home on floating trees, buildings burst out the sides of steep hills; only rooms next to the outside had natural light. Caves farther in required artificial light or long light tunnels. In this atmosphere, nothing floated, nothing of a reasonable density. Large rocks, which sank on his home planet as well as this one, formed a surface that did not glow, was not under too much pressure, and mostly lacked caverns. Buildings sat on top of the ground.

Three standalone towers stood much higher than even the tallest cable tower. He stared at the closest. Leestel said, "We like looking down; that is why we climbed the hill on Ulterius when we first arrived. That's what those towers are for. There are no high hills nearby. We can climb them and look out. They enable us to see the city differently."

Gell shifted his attention away from the tall towers. They looked as if they were built by piling stone blocks on top of each other, not unlike the other buildings. "The cable technology looks ancient." Gell said. The car was moving over another tower and Gell was looking at an obviously mechanical safety lock that stopped a car coming out of the station from colliding with any other car.

"It is ancient," said Leestel. "Children can understand how the system works. Moreover, they can steer. That ability provides the kind of control that humans want. Nobody minds not steering, but people want to be able to steer if necessary. You could do it. To steer, move the bar to the right when crossing a tower. That switches us to another route. Gravity powers that part of the ride. Then it is easy enough to grab a different cable to haul us to another tower. Nowadays, of course, computers mostly steer. But the human capability is there."

Leestel introduced Gell to her parents. "Lanset and Loerri Beldon," she said, "meet Gell, the Envoy from the Tree Tortoises."

Gell said he was pleased to meet them, but then asked about the last names.

"Your last name is Kemmel," Gell said, pointing at Leestel, and then shifted to her parents, "but your last name is Beldon. I thought human last names were passed on."

Lanset said, "She changed her last name . . ."

Loerri said, ". . . when she was old enough to."

Lanset said, "She did not like us much."

Leestel said, "That was a long time ago. I was feeling young and overwhelmed, mostly by my mother."

Loerri said, "I am not sure quite what it was. We enjoy gardening; that is our hobby. At work, I strive to prevent unwanted fires. That is my profession. Fire prevention has been my job since before I left Earth. When I started, we did not have robots who could see how to prevent fires. We humans had to do that. We did not have easy access data at that time either; I studied. Now robots see what needs to be done and I deal with people."

She smiled grimly. "I deal with infrequent events. If they happen, they inconvenience people. Fortunately, highly inconvenient events are very infrequent. Unfortunately, people seldom think of themselves as in danger, but they are. So I try to teach good habits. No one is going to adopt inconvenient habits. They might, but probably won't adopt irrelevant habits. An example of an irrelevant habit, one that once was relevant, is scratching a match. It used to be a good idea to scratch a match away from you. Now, who cares? Few employ matches and those that do scratch matches that are well made. Burning heads do not fly off them.

"People will learn convenient habits, but there are very few of them. Mostly, people learn them when little, such as not to carry anything to bed that burns or smolders. As an adult, it is worth checking a detector once in a while. Since they almost always work, it seldom matters if you forget and delay a while."

"I am an actuary," said Lanset. "Computers do the calculations. I talk with the people. With assemblers, material goods cost nothing but time; for insurance, the issue is inconvenience. When your house is destroyed, the question is no longer whether you can afford to have it replaced, but how long will you have to wait? Fire prevention tries to halt inconvenience of one type and insurance deals with it.

"Most people do not buy fire insurance. They simply endure the wait and the inconvenience.

"Similarly, with rebirth, death becomes less fearful. People once were very concerned. Now they are less concerned.

"However, unexpected death means the loss of the time since your last backup plus the loss of at least two years while a new body is grown. (Most people do not want to enter a standard body. They prefer to wait.)

"Mountain climbers are injured or killed fairly frequently. In our society, they take bigger risks than they should. On Earth, mountain climbing was remarkably safe.

"The likelihood of a mountain climber needing a new body is sufficiently low that none are grown ahead of time. However, the likelihood is sufficiently high to make it worth obtaining insurance for death or injury. Indeed, mountain climbers are my main customers.

"Injuries are treated by robot, which does not cost anything. However, humans help afterwards, and humans cost!

"Also, of course, status and centrality remain; but you cannot insure for them.

"For the first gross of years, we lived in a large house," continued Lanset. "Then we realized we did not need so much room and could expand our garden instead.

"We call this the 'small house' even though it has been more than two gross years since we had the 'big house.' "

"I grew up in this house," said Leestel.

"It is not such a small house, either, just in comparison."

"It is not small by Earth standards, . . . " said Loerri.

". . . at least of normal, European houses."

"We like growing flowers and vegetables," said Loerri.

"This place has a wonderful climate for that," said Lanset.

"We were together for more than two dozen years before we left Earth. Most of that time we never suspected there could be a better place. The first dozen years, all on Earth, were the worst. We nearly split several times. Then we became accustomed to each other. We have been together ever since," said Loerri.

"We even brought up Leestel . . . ," said Lanset.

". . . Who turned out well," said Loerri.

"Your gardening reminds me of when I was in my original organic body, of home," said Gell. "On trees householders keep plots of land, at least some of them do. Not every tree tortoise likes gardening. On those plots, they grow what you can only call plants — biological entities that cannot move, have a root system that gathers nutrients from the regolith or soil. They have leaves to collect nutrients from the atmosphere and energy. A few are colorful. Like your flowers, those colors attract our equivalent of animals that then go on to other plants of the same species."

Then he managed to look a little chagrined. “I don’t know much about gardening, either there or here.”

“Your internal transceiver enables you to access human data,” said Lanset.

“I didn’t think of that,” said Gell. “We don’t provide such widespread information, or we didn’t.”

“We have spent years,” said Loerri dryly, “becoming dependent on what we could access.”

“I did not imagine the size of your net. During my deep space trips,” said Gell, “I studied astrophysics, watched traditional dramas, and even read what you would call novels. The first and the last required an information transfer mechanism that depends on my understanding a code that I learned overtly.” He thought for a moment then contradicted himself. “That is not true. I did not have to learn to read; I could depend on a text-to-speech synthesizer or a smart computer. But I learned to read when I was young.”

Leestel spoke. “Visual reading is convenient. Although the stream of thought conveyed is one dimensional, you can look in two dimensions and easily skip what you don’t want. Text-to-speech synthesizers and computers can talk quickly, so slowness is not a problem. They increase the speech rate slowly and almost unconsciously; people learn speech that is quickly spoken in a very short time without effort.”

Both Loerri and Lanset nodded. “We have text-to-speech synthesizers . . .” said Loerri, “. . . even though we most read visually,” said Lanset.

Gell thought of the disadvantage of being read to. “An audio stream does not come in two dimensions,” he said. “On the other hand,” he used the human phrase, “a writer spends a huge amount of time choosing what to say.”

“Yes,” said Lanset. “People like to communicate what we consider strange. Traditional dramas, which can be written or viewed, and modern knowledge: those come first. The people who enjoy them are crazy. Gardening comes later.” Lanset sounded and looked reasonable, but Gell noted that Loerri had a hard time keeping a straight face.

Lanset went on and Loerri regained her composure. “I bet you don’t care much for gardening, whether it be tree tortoise or human. You left your planet and entered an inorganic computer. That life does not even require organic recycling, the way humans in organic bodies need plants. Well,” Lanset paused dramatically, “you dislike gardening. Many do. We won’t hold it against you . . . much.”

This time, both Loerri and Leestel began laughing. After a very short pause while he considered, he smiled. That was the right response. Lanset was hurt that Gell did not care for gardening, but did not want that to come between them. So he joked instead.

Gell asked, “How is reversion going to effect your being in this house?” A law had just been passed. The President and the Founder of Melior, Eltis Akthorn, would be the first to revert. She would lose the Presidency.

“We are going to lose it in about two dozen years,” said Lanset.

“But I am going to be traveling back to Ulterius then!” said Leestel.

“If you make provision before you leave, then all will be well. I hope you will decide to give it back to us.”

“Of course,” said Leestel. “I think of you as here always.”

“If you don’t make provision,” said Lanset. “the house will go into a general pool. That’s because you will have gone and communications will take too long. If we seek the house, it will probably come back to us; but there is no guarantee. Mostly, reversion is aimed at people more central than we — it is to give your former colleagues in the civil service an opportunity to succeed their predecessors, that sort of thing. Still, the general idea is to shake up everyone; and it does.”

Chapter 19

During the first interstellar voyage to Melior, the data packet for Djaems Vin Bevin, a friend of Filgard Meldon, was destroyed by an errant cosmic ray. The data packet traveled successfully on the second trip, Djem's, and he was woken into a biological body not long later. Gammae helped him adjust in the same way she had helped Djem.

Djaems was an astronomer. He was not obsolete as he expected even though he woke more than two gross terrestrial years after the other migrants and nearly four gross years after his last update on Earth. Progress in astronomy had slowed, both on and by Melior and on and by Earth. The last was according radio transmissions from Earth sent by the Melian AI there.

Djaems felt that the lack of Melian astronomers made slowness somewhat excusable. However, a good portion of the population was Expansionist. Such people ought to be interested in what was out there. They should provide more astronomers.

Moreover, Djaems considered astronomical observations the basis of every understanding. But then, he knew, everyone felt their own profession was important. Still, he wondered, why didn't Expansionists propel more people into astronomy? He did not understand.

For his second and third bodies, Djaems woke into inorganic substrates, like Djem and Leestel. He had been persuaded by Airlent Irtak that an inorganic substrate brain provided a wider range of perceptions. Moreover, they would be more beautiful and more useful for him professionally. He continued with an organic, human body for the rest of himself. Only his friends and the computers knew his mind was not organic.

In order to see high resolution low frequency radio data directly, Djaems needed special adaptations. These were additions to his brain. Fortunately, constructing them was no harder than extending his high frequency visual light range. That was already done for all with inorganic substrates, both AIs and originally organic humans.

Djaems focused on other galaxies. He remembered that collected information, a third of the way through the twentieth century, in the 1930s, a base ten date that made sense for Earth, Zwicky had published information that stars farther from the center of a galaxy orbited faster than could be accounted for by the mass suggested by the galaxy's luminosity. Volders' later confirmed these observations. Quicker orbits said more gravity. In turn, that suggested either more mass, which could not be luminous otherwise it would have been seen, or changes in the notion of gravity.

Djaems understood his profession when he became awake on Melior. As far as he was concerned, that was wrong.

Djaems was newly into his third body when Gell arrived and wanted to meet him. "The alien is an 'astronomical character,'" he said. "The alien has crossed interstellar space." So had Djaems and all the other Earth-born people on Melior, but that was neither here nor there. Fortunately for Djaems, Gell was as curious about the astronomer as the astronomer was of him. So they met. Gell was surprised that Djaems wanted him to tell the history of aliens.

The human had all the data Gell provided, including histories. Djaems had adapted to Melian tools and computers; he wanted Gell's understanding. "You are smart," the astronomer said, "you study humans. The histories you have provided are for other tree tortoises."

"I don't know much history," said Gell. "No,' said Djaems, "that is not your profession. Worse, you are a sample of one, which is very bad. But you are all we humans have. So we will make do. Besides, I am curious what a non-historian has learned. I don't study history professionally, either."

"A tree tortoise named Alguldintirn," said Gell, "made it possible to have warships with multiple rowers. Feathering had been discovered much earlier, before written history.

"Like modern, single tree tortoise rowing, all earlier rowing had a tree tortoise pull the oar towards him. A few boats had two tree tortoises side by side. Pulling is strong, but in that position, a tree tortoise takes up more space than a sitting human."

Djaems was confused for a moment, then he understood that Gell talked of a tree tortoise pull. That was towards the long length of the fish-like body, in contrast to a human pull, which was towards a person's chest. Tree tortoises did not sit on benches.

Gell went on. "When tree tortoises pulled, they pushed into a padded, circular brace, with two beams going to the boat. The reverse required two straps holding another circular hoop.

"Alguldintirn's invention, or innovation, was to have the tree tortoises be a quarter turn from the direction of motion and move the oar back and forth rather than pull and push it. Tree tortoises cannot be as strong doing this as when they pull; they are like humans waving their arms over their heads. But tree tortoises are not weak, either. With many tortoises in a boat, you can move a galley faster than a swimming beast can pull an armored knight."

He paused for a moment. "Previously, warriors had been pulled by swimming beasts; both were armored." He returned to the design of boats.

"You can have two banks of oarsmen, one bank on each side. One bank or set of tree tortoises goes up and the other down. With rowers placed ahead of you, you humans could say 'above,' we tree tortoises would say 'forward,' you need a circular cross section in the boat with

straight beams across it for the rowers. Fortunately, circles were easy with the old techniques. Builders bent big hoops. With padding, the beams held the rowers as they paddled the boat foreward; simple straps served the other direction. They did not need a circular brace or moveable hoop.

"Nobody wanted to be vertical, but they wanted to win more.

"Because a pulling tree tortoise takes up a complete body length, a galley with vertical oarsmen had four at every place where there was room for only two before. Yes, the two pulled and were stronger than two moving oars sideways. But four had the strength of three. Moreover, many rowers worked together, not just two or four pulling. With more oarsmen, a ship was bigger. A bigger ship carried more armored fighters. They did not need beasts; the logistics were easier; the fighters were cheaper. When a ship reached a warrior using the older technology, a swimming beast pulling a knight, fighters could swarm about him.

"Alguldintirn gave his tree the idea for such ships and they built and crewed them. Those ships conquered the rest. Alguldintirn's name was shortened to Tirn. That is our history!"

"I am sure there is more to it than that," said Djaems, ". . . how Tirn got funding for his ships, why so many were willing to be oarsmen and fighters, how his people treated people on conquered trees; but I am more interested in the technology. How did galleys get steam engines and propellers?"

"Steam was a much, much later development. Mechanical power changed everything. I think it did more for us than electricity. It is not so clear about you humans.

"Regardless, unlike yours," said Gell, "our first steam engines did not have pistons. They were rotary engines, similar to your Wankels.

"A fellow looking for a pretty curve first drew the proper shape. He was a mathematician. Everyone else had put a pen inside or outside a single wheel; he put his pen outside a wheel, the inside of which rotated around another.

"Much later, after dried seeds came to be used as a high density fuel for pressure cookers, that shape enabled Teg to build the first rotary engine. He was a true genius. No one else could have imagined each chamber expanding and contracting during a turn. No one else could have developed the requisite seals. Later engineers added valves and extra rotors, but he started it all.

"The first steam engines were weak. They leaked. They did not make very good use of the steam. The pressure was low. As a practical matter, they could only power tiny fans, nothing else. But Teg improved them. He made a power source for a lathe. That was important, since previously, any lathe that required more than hand power needed to be located on a tree by the natural stream of a liquid that condensed at

our temperature and pressure. There are not that many such streams, fewer than your rivers.

"More than generation later, steam engines became powerful enough to operate fans that propelled ships. The police funded them, since ordinary people rode in boats pulled by swimming beasts. You could armor animals, but never as well as the hull of a ship. Incidentally, because of the world government, we had not had an army for years and years. It was called an army, but was really a police who patrolled the regions between trees and occasionally put down revolts.

"The first ships were simple galleys. They were retrofitted with dried seed bunkers, boilers, steam engines, and fans. Their rowers rested when the steam engine worked. That was key. Revolutionaries in old style galleys got exhausted first.

"Each steam ship carried few armored police since its steam engine, boiler, and fuel filled the space that would otherwise have been occupied. But it could and did tow a regular ship with lots of armored fighters in it.

"Within a short time revolutionaries adopted steam, too, but that made revolt more expensive. In those days, only trees had the capability. Now with assemblers, anybody can produce anything material, but not in those days. Few trees revolted and the central government did not require many ships. But their existence did show what was possible. People on other trees imagined and eventually got the funding for more peaceful uses."

"How do trees come into history?" asked Djaems. "I think of them as similar to clans."

"Clans might be a good metaphor," said Gell. "I am not sure.

"Our unit is a tree, which is to say, all the people on one. Unlike clans, people are not related genetically, not most, not in any way that was known in ancient times."

"What about trees with internal dissension?" asked Djaems. "Couldn't opponents hide in caves?"

"Yes, they could and did," said Gell. "There were two reasons that was not a problem. The first is that Tirn's soldiers did not go into trees; they were only concerned externally. The second reason is that one side was always more persuasive than the other, even if only a little bit. Over several generations, the more persuasive influenced the children on the edge — the others only heard one side — and when they grew up, they fought and won another cave."

"I had forgot how slowly you changed," said Djaems.

"Soldiers can control a tree externally," said Gell. "However, it is or was expensive, perhaps impossible, to investigate every nook within it. So you had to punish a tree as a whole.

"Because individuals could hide, many different kinds of people could live on a tree. Indeed, even after each tree came to have only one government, so long as the people were not too dissimilar, the more conservative protected the more reckless, who bring on punishment. Also, in the past, an external government did not want to punish a tree too much, since that reduced revenue. So a degree of tolerance was permitted and became customary.

"To answer part of your question about Tirn's conquest: he suppressed piracy and did not charge much for tariffs. That was important; the merchants ended up supporting him. His people did not seek much, so the people on trees did not feel worse off or humbled. That was important, too.

"Tirn and his successors did restrict traditional items. That was an advantage since it meant that profits went to those who were not directly in the government. Also, other trees could develop technology as a route to wealth.

"Outer, non-central trees became the sources of new technology. The people in them wished to make more money. They wanted to get around restricted technologies without being attacked. On the other hand," he spoke the human phrase consciously; he swung a hand; as a tree tortoise, he would have used the phrase 'on the other side,' "as they became richer, non-central trees became more central and pushed for more legal restrictions on their own technology. Consequently, they innovated less."

Djaems thought about that. Then he asked, "What about another technology, writing. You may not think of it as a technology; many humans don't. But it is as important as anything military. I know you have books and writing; I can access them in my mind."

"As you can see, modern printed tree tortoise books looked more or less like printed human books," said Gell. "They aren't scrolls or anything like that."

"I see," said Djaems. "They sit in a protective cover, just like ours, and their contents are printed on pages that are fastened on one side only. Are pages glued, like printed human books?"

"Yes," said Gell. "Older ones were sewn, again like printed human books."

"However, I see," said Djaems, "that printed tree tortoise books are tall and thin compared to human books." He paused for a moment. "According to my calculations based on the electronic images of what you have supplied, for a good number of pages, for a good lot of different books, the height of text for your books is about phi plus one times its width rather than phi times its width as among human books.

Djaems knew that phi plus one equals phi squared, the only number for which that is possible. However, he also knew there are many other

strange numbers, so he left phi behind and said to Gell, "Many human commentators say that hardly any designer cares or cared about phi. They say that designers made rectangles a little squatter, their heights one and a half times their widths or thereabouts."

Then he thought about phi more, "However, a rectangle with a phi or 'golden' ratio is easy to construct with string and straight edge: divide the side of a square in half, connect that point to an opposite corner as a line, and swing it down. My hunch is that apprentices did this and later developed an 'eye.'"

"I don't know," said Gell. "In contrast to you, or at least in contrast to your most common written text, in which lines always start on the left, our text starts at the top right, goes down for its first line where yours goes across, and then goes up for its second line."

". . . boustrophedon," Djaems said.

"What do you mean?" asked Gell.

"My apologies; boustrophedon is jargon," said Djaems. "It comes from the words 'ox' and 'turn' in ancient Greek. Supposedly, the path a reader takes on a page is similar to the path an ox took on a field when plowing, turning at the end of each row to return in the opposite direction.

"Your writing does that, except it is vertical. Among humans, I know only of horizontal boustrophedon.

"Do you run numbers in the direction of the text or always write them with the smallest value on top?"

"We always write them with the smallest value on top," said Gell. "Otherwise, the biggest value would be on top sometimes. That would confuse."

"Yes, I can see that," said Djaems.

"What about electronic displays? When do you turn lines around? Displays have no built-in dimensions. Nowadays, human displays don't bother with pages at all."

"External displays do have built-in dimensions," said Gell, "their physical height and width. Programs must discover them and format displayed text so it fits. We cannot display unformatted text as you humans do. We always format. You do, too; you just don't think of it."

"What do you mean?"

"You can carry on a single line of plain text forever to the right. Yet displays have a width."

"Nowadays, most human text is specially formatted, too. For example, headings show differently than content," said Djaems.

Gell considered the display most common among the humans he knew and becoming common among tree tortoises. "Internal displays,

that is, displays that don't go to the edge of the physical screen, lack built-in dimensions." Djaems nodded.

"In them," Gell continued, "we create artificial displays that have the same ratios as printed pages. They show letters and numbers with the angular dimensions that most find comfortable."

Nodding more, Djaems said, "That is what we do, too."

Djaems thought more. Gell had provided a good deal of information, but Djaems did not know what was relevant or what would happen. "What happens," he asked, "when people in a tree discover that a assembler can produce anything material? I am particularly interested in how you will handle changes in trade among trees. In the past, trees bought a vast amount from other trees. You spoke of non-central trees innovating new technologies as a way to sell more."

"Trees," said Gell, "are going to have to switch to producing and exporting services rather than materials. That is going on now on Earth. There is no reason it cannot be done equally slowly at home, or more slowly. Customarily, we tree tortoises take longer to make social changes than you humans.

"Another advantage we tree tortoises have over you humans is that we do not need to monitor within trees. External flows serve well enough. The quantities of material trade between trees are well known. They have been stable for years and years. If a tree produces more by itself, the central government can force that tree to pay another an amount equal to what it would have paid had it imported the extra. In other words, a tree is not helped by having its own assembler. I don't think you humans can do that because your production relations are not so stable, not over years and years as ours have been."

"Our central government can enforce its between-tree rules everywhere. It can control trade between trees. Morover, it will do so intelligently, rationally, and with a long term view in mind. Most trees will support an action even as they complain.

"On the other hand, from what I have seen, your human history is replete with governments that had laws whose purpose for senior people was to prevent progress that might go against them and whose purpose for junior people was to enable them to collect money from those who wanted to go around the laws, or speed up applications, or whatever."

"That is true," said Djaems. "Worse, when I was on Earth, it did not look as if any world government would ever act 'intelligently, rationally, and long term.' When the technology made it possible, we gained successively several countries that acted as world governors. Unfortunately, none called itself a world government. Almost no one else did either. Moreover, none did well on a world-wide basis: the people in them acted stupidly, irrationally, and short term."

"On Earth," said Djaems, "a profession focused on scarcity. As I remember, individuals mostly directed their attentions to items whose production was limited by the physical technologies of the time rather than by political constraints."

"Nowadays, political constraints are vital. Assemblers can produce anything," said Gell.

"Not anything, but many things," said Djaems. Gell subsided. Djaems was persnickety. And he thought of 'attention' as a thing.

"However," Djaems added, "I agree that political constraints are vital in the present. In the early days, physical technology was important, too. It still is, but people forget.

"A question arose in the early history of the profession of economics — I was going to say, 'an early question,' but it was not that early in the history of humanity. The question was what 'the price of tea in China' had to do with you, presuming trade existed between your region, which was not China, and China, a distant region. It did not matter whether you drank tea or knew anyone who did.

"Nowadays, of course, we do not trade material items with China, which is on Earth. Assemblers make items here on Melior. Information is not traded either, at least, not directly. Tea is assembled by an inorganic replicator or grown by an organic replicator. Interesting!" He learned from his connection to an external memory. "I did not realize it, but with robots doing the work, tea on Melior is mostly grown by organic replicators.

"Inorganic assemblers are irrelevant to this issue. I am talking about the period before anyone left Earth, before their invention. John Von Neumann was a well-known human who wrote about them; that is why they are sometimes called Von Neumann machines."

"I know about your John Von Neumann," said Gell. "He had no connection with tree tortoises, none at all. We had assemblers long before you humans. You thought of them before you came into contact with us and invented them independently."

"In any case," said Djaems, "individual professional explainers of that period seldom focused on activities with decreasing technological costs, like armies or skills in reading.

"A good number did not look at political constraints either, even though the production and therefore the cost of many items, shoes for example, was determined as much by the businesses that made them as by the technologies. At the same time, other centers of power failed to look at or were unable to enforce needful regulations.

"Partly, I think, that lack of focus came because these other centers of power could not enforce their choices and partly it came because of a false but widespread belief that being compelled by a private entity was less coercive than being compelled by a public government. I think the

belief came from people who could not imagine leaving a country with a powerful government but could imagine living in a country with free and competitive markets, without the food, clothes, or shoes produced by oligopolists, often corporations.

"Instead, economists studied 'the price of tea in China.' They assumed that the tea was grown by a multitude of independent entities, that each entity faced increasing costs, that transport consisted of a multitude of independent ships, that no organization along the way had any influence on the amount produced or carried, and there were no unpriced bads along with the goods of production and distribution.

"What they found, of course, is that others' consumption of tea influenced the prices you paid for different items, such as shoes or shirts, even if you did not consume tea or know anyone who did.

"That was dramatic, because humans tended to consider only what they themselves could see."

"That makes sense when your only influences are close by," said Gell.

"It stops making sense as soon as trade covers long distances," said Djaems.

Chapter 20

Seegraev Wilson became leader of a new group, those who were upset by the alien tree tortoises' potential use of the Ulterius system's interplanetary resources.

Wilson had been a member of the 'Earth Beware' party, but he had not been its head, like Djaeds Summervil after Gellor Thurnsby. His new group was very much of the belief that aliens should stick to their own. They called themselves and were called by others the 'Alien Beware' party.

More precisely, in the Ulterius system, and in others that humans might settle, they thought that whoever came first should get it all. Most did not think that the aliens would cheat on their treaty. Few thought they would take more than their share. The members of the party and Wilson in particular referred to them as 'aliens' rather than as 'tree tortoises.'

In her first meeting with Gell after welcoming him and after the reception. Eltis spoke to Gell of the 'Alien Beware' party. "Most likely," she said, "the opponents of sharing will go along with the majority. As a group we Melians are a peaceful lot, not like those who remain on Earth. I doubt that any of our people will misuse an assembler, either. Earth is a different matter, although they cannot kill every tree tortoise.

"Most Earth people didn't know about their assemblers. Djem did not know about them. The Earthly powers that were did not use them to end material wants. That ignorance is somewhat helpful. When you don't know how to do wrong, you can't do it. On the other hand, by now the news has probably spread dramatically. Recorders, assemblers, rebirth, and reversion all fit together."

"They do among humans," said Gell. "We have had recorders and assemblers for a long time, but not rebirth."

"You have had rebirth into inorganic substrates," said Eltis. "In any case, and I think it is rather fortunate, no one can fight an interstellar war against another species that has assemblers itself. An incoming space ship must either slow itself down or hit at one-quarter the speed-of-light. If a space ship slows so it can build more assemblers or drop bugs, it can be found by a dense sensor network and be destroyed. If it does not slow and is not discovered, it can produce a very large explosion.

"Several space ships can together increase their resolution and discover where most are. With less warning than for comet impacts, more people can get killed. But not everyone will die. With assemblers which exist in space, survivors can retaliate.

"No one rational is going to go for that kind of mutually assured damage, by which I mean, no one rational is going to attack you. And

even with assemblers, I don't think the irrational can secretly build the power plants and the rest that are needed to launch interstellar.

"So I expect talk but no danger." It never occurred to Eltis that Gell himself might be attacked.

Shortly after seeing Gell, Eltis went to talk to members of the 'Alien Beware' party. Unlike the heads of political parties, she listened to everyone. This time she intended to speak. She started by saying, "Yes, they are going to expand. That is for certain. Would you favor interstellar migration?" That was a rhetorical question, since all except the few born on Melior had migrated. Her whole immediate audience had migrated from Earth.

"At the moment, there are not that many aliens in the Ulterius system. A dozen or so are awake; the rest are in their space ship. We do not have to worry about this few a number using all the resources. However, as you say, we may end up with a vast number of them." Her listeners all nodded. So far, they agreed with her.

Eltis looked concerned. "We want to persuade the tree tortoises to limit their population," she said. She spoke of 'tree tortoises.' She had noticed that Wilson did not use it. Most likely, she thought, because 'tree tortoise' was a friendlier term than 'alien.'

"When they limit their population, they won't have a big impact," Eltis said. "I agree, if they don't limit their population, if they grow it too big, the tree tortoises will take all the interplanetary resources. That would be very bad for us humans."

Then she asked a question and answered it in a statement based on practicality. "How can we fight them? We can't, not with violence. We cannot send destructive assemblers to Xi Bootis; the tree tortoises could discover and intercept them first. Automatic machines could retaliate if they failed."

Wilson had an answer. "We do not have to worry about their home people hurting us because of fear. 'Mutually Assured Destruction' has its uses."

Eltis countered, "Why shouldn't we expect them to kill all the humans in the Ulterian system and settle in all systems with Jovian planets that have a high enough magnetic field?"

"Why, indeed?" asked Wilson. "They might. Some systems have both their kind of planet and our kind. We should kill them first."

"You want to kill the tree tortoises forever?" asked Eltis.

"They are backed up," said Wilson. It had never occurred to him they might not be.

"No, they are not," said Eltis. "They all are alive in computers. That is why their interstellar space ship carried so few. You would kill them forever."

It was clearly visible to Eltis that Wilson did not want to kill the tree tortoises forever. Eltis thought that was to his credit.

Eltis went on, "At the moment, only two of them, Moel and Gill, are backed up. We are teaching the tree tortoises, but at the moment, they have to go through us.

"Moel would have died when we, ignorantly, tried to extract a backup from her. She carried explosive that had been put into her brain by their police. It was designed to explode if a receiver detected a 'strange' radio signal. Our radio signal for a back up was 'strange.' Fortunately, the circuit to set off the explosion was slow. We were able to copy her. So she was reborn with a memory that went right up to the time she died. Effectively, she suffered no loss, except for a bit of time. Gill has more complex circuitry that our radio does not trigger. He never died; we did not learn for the longest time that he carries explosive, too. His backups have never been used."

Eltis shifted. She did not say anything about what might happen when tree tortoises eventually learned how to back up. She mentioned the notion primarily to jar her listeners. She felt she had to shock her audience a little before her next topic, considering the universe from the point of view of tree tortoises. This was a standard empathy employed by successful generals and other predators, but not by everyone. "Some tree tortoises are going to be anti-human," she said. "They will argue that we come from small planets with hardly any atmosphere and should have no rights to resources."

She made the important point, "We want to make sure evil tree tortoises never gain power." She consciously used the emotive word, 'evil.' "The tree tortoises could cause us a good deal of trouble. Wilson is right, they can cause a great deal of damage.

"At the same time, tree tortoises cannot destroy us humans. They cannot do that any more successfully than we humans can destroy them. But they can hurt us, just as we can hurt them. That is what I am trying to avoid."

She went on to say, "Presuming that they don't have a population and impact control program already, our only hope is to persuade them. That is a different kind of warfare. Strange as they are, they must believe us." She not only looked concerned, she worried, albeit not much, that the tree tortoises would take all the resources.

"They must believe both that we are truthful and that we make sense."

At the same time that Eltis spoke, two humans stalked Gell.

In her speech, Eltis paused, then she said, "Of course, both sides could fight unsuccessfully. I doubt anyone wants that. Failure produces damage with no compensating loot.

"And that is what the resources are, loot."

In one way, Eltis was saying that war provided loot for victors; in another, she was saying that gathering too many resources was war. She stopped for a moment because she felt the next question was key and she wanted people to digest her claim that gathering too many resources was war or a kind of war.

"So how do we argue that we are truthful and that our position makes sense?" She paused again. She wanted to persuade. If she failed, she expected unsuccessful fighting between the two species. Failure might happen.

She redefined warfare, not as violence, but as a change in the enemy. "What are the requirements for a fight? They won't be persuaded that we will be good to them if they see us increasing our impacts too much."

She held back for a moment and then stated the obvious. "Not many humans have gone to Ulterius. The population is low. We won't have much impact unless we have assemblers do something truly crazy. We won't do that. Nobody expects or advocates that. If we do, we deserve to lose. If they do the same, they deserve to lose. Both we and they understand that. So impacts and both our populations can get bigger. Only when impacts and populations get big enough do we need to halt their and our growth. That is the long run issue."

Gell was walking beside a water pumping station when the stalkers pounced. The station had been built for resilience. Unlike the rest of Melior, its own pumps did not receive electricity from a space-borne satellite that never went into shade. The station received electricity from batteries that were fed from electricity produced by local solar voltaic cells during daylight or from helium three fusion reactors. The reactors were designed to operate during long periods of rain or dust that could stop sunlight; an unrefilled supply of helium three would not last as long as solar cells.

More to the point, not only were the electrical devices in the station shielded from electromagnetic pulses, as were all other electrical devices whether in the station or not, rooms in the station were shielded so everything in them carried more protection. Windows let a maximum number of visible light photons through, no more; they did not permit the entry of any other electromagnetic frequency. In particular, without working repeaters or a wired connection, Gell would not be able to signal rescuers.

Eltis came to the crucial point. "The short term is a matter of figuring out intent. So long as nobody does anything crazy that is not stopped, neither we nor they will more than touch resources.

"It is not simply a matter of making a good argument; we must persuade them to believe that we will follow the argument when the time comes. Otherwise, they will come to think that we are lying.

"Only by living our actions can we persuade entities who are very different from us."

She paused again. "We can look at their actions to determine whether what they say is what they do. That is all we can do. Similarly, they can only look at our actions. They will not trust our words any more than we can trust theirs.

"In the meantime, they already know about backups. We told them, but they would have discovered them anyhow. With dead data-packets, many more tree tortoises can move interstellar than now. As far as I can figure, they, all of them or at least the migrants, have no antipathy against backups. So either they will develop the technologies themselves or we can help. I mean the tree tortoises on their home planet by Xi Bootis. Our help will speed up the process a bit. It will put us in a better light, too.

"Until we do that, any we kill who we haven't backed up, we kill forever."

As she was leaving the meeting, Eltis wondered about an older effort, to encourage physical presence among reborn humans. With internal computers and communications, no one had to be present physically. People could become self-involved and isolated. Civil servants created temptations to encourage the opposite and apparently they succeeded! Since she preached physical presence, she had to appear physically. Strangely, many others came, too.

Then suddenly one of her robots stopped and held up both hands, elbows bent, palms facing her. Eltis stopped her exit. She knew something was not normal.

The robot said, "The alien envoy is being attacked. His guard is not with him. He dismissed it as not being needed. He walks in different parts of the city without suggesting that he is not human. I suspect he is trying to understand us."

The robot continued. "Now Gell is being carried into a pumping station . . . and we have lost communication with him! The attackers must have cut off its repeaters; that station is designed for disaster; not only can it pump water, provide power from internal sources, and house refugees, it has a very good screen against non-visual range electromagnetic radiation. Without repeaters, communication is blocked. Just now, its video cameras went off line. Normally, we can access them. Now we have no way of learning what is going on inside except by going in."

"Normally, this is a safe city," said Eltis rather stupidly. "A person who looks like a random human, like Gell, should have no trouble. The attackers must have been looking for him in particular."

"Before the attack," the robot said, "the attackers, there are only two of them, were not visible to cameras, or perhaps they were, but could

not be distinguished from others. At least, that is the information we have at the moment. During the attack, the two wore hoods. And now they have gone out of range.

"It was well staged. Someone wearing a hood jumped out of an ally that we do not monitor. According to preliminary analyses of body movement, that sentient was male. From behind, he dropped three loops onto the envoy. One fell to his feet and two others swept around his arms. The man pulled the loops tight and Gell could not rip off the cloak and show the fellow's identity to a camera or to himself for that matter. Last we could see, the envoy was wiggling hugely, but not hitting the attackers. The initial analysis suggests that both are male.

"There was not anyone else outside that door into the station. Gell was following a rarely used short cut. There are many people on the other side of the station. We can send in a few robots immediately; there are not any sentients that the Envoy knows close by; no, that is not true; by happenstance, Tindark is close; nobody else is. Do you want me to send Tindark and others that the Envoy knows or call a general posse? We can send robots, too."

The robot suddenly jerked a little; he had learned something he had not expected. "Maybe collecting numerous strangers is not so good. Only those with wired connections will be able to tell when Gell is found and there are not that many wires. Once we get the repeaters working again, we can send lots of people."

Eltis was definitive. "Send the robots to the repeaters, ask Tindark to go in. Presumably, after the repeaters start working, the system will discover where Gell is and Tindark will be able to go to him directly. I don't want a large number searching for him because that will make a bigger story than I think it is. Only if the repeaters are dreadfully destroyed and cannot be replaced quickly, will we need a general posse."

The attackers took Gell to a distant room. There, they tied his hands behind his back and tied his feet.

One attacker told Gell, "We are not going to kill you. That would not do any good. You are backed up." Gell was, but this man thought all the aliens were backed up.

"Our intent is that you come to hate humans. Tell your people to avoid them. Don't settle in systems with humans in them. Stick to your own. We know we cannot kill your species. Likewise, you cannot kill ours. But we can avoid each other."

The other attacker said, "You will be found eventually. You will be able to report home. But it is unlikely you will be found soon since your rescuers will need to investigate every part of this station; and we have not put you in any obvious place. Think of this as a message."

Gell was dumped on the floor. He fell on his front, with his head arched back and turned to one side. Holding his head back did not keep

it from the floor. When he hit the floor, he banged his left ear. That hurt more than he expected. Until he cut the amplitude of the signals, he felt it strongly in the inorganic substrate of his mind.

Cutting the pain reminded him that he really was two beings, not one. His mind was in a robot body built by a tree tortoise assembler; it was inorganic. Humans had force-grown the organic body which he inhabited. However, he did not have to stay in it. He could disconnect from it, leave it, and use his own sensors and manipulators. The organic body would lose its mind but presumably would not die immediately.

Shortly after his attackers left the room, he left his organic human body. The room looked strange to his regular sensors. The windows cut off electromagnetic radiation just below the frequency which humans called 'red'. He saw only the higher frequencies of his normal range, no 'blue.' Still, he saw enough. He untied the bonds which held the hands of the organic body behind its back — he did not have to use the manipulators to snip through them as he thought he might — and then went to the bonds holding his feet together. Finally, he reentered and reconnected to the organic body. In a strange way, he found that a relief. He had grown accustomed to the human sensorium; the room looked as he thought it should.

Nonetheless, he reduced the pain the organic body persisted in producing. After putting a hand against the wall, he was able to get up. Then he could walk out of the room.

He had a ways to go. The station was big. It was not the wells, pumps, helium three reactors, or helium three tanks that enlarged it; it was the solar collectors. Sunlight provides a diffuse energy source, although it is not as diffuse as the multiple helium three reactors, which took up more volume at Melior's distance from its star. If the reactors had to be used, not as much electricity would be produced. The robots that built the station put the collectors on the tops of rooms they intended for other purposes such as storage or emergency living. Although providing water was its everyday function, and what it was called, the station was designed to do more.

In a second hallway — clearly, Gell had been dumped in a seldom visited store room — he saw a thin cord that snaked into another room. That puzzled him. He had not seen such a cord before. He followed it. In the room, he found Tindark. The man was going into each room and looking for him.

Tindark said, "Thank heavens; we have found you, or you have found us. Just a moment . . ." He looked blank and then said, "I have told every one else where you are. We just need to follow this tether to get out." Gell was puzzled. "How did you tell every one?" he asked. "I have not been able to communicate out; I think that is why my attackers dumped me here."

"The tether," said Tindark, "transmits signals back and forth to the outside. I am carrying the rest of the line rolled up because that is easier than pulling it along." The roll was attached to a belt that went around Tindark's waist. "The villains have either turned off or destroyed the repeaters and sensors in this station." The word 'villain' amazed Gell. He read a sociologist who said that few used the word in speaking even though it was well understood. Either the sociologist was wrong or Tindark was among the few.

Tindark walked out with Gell. It was not far, unless you had to look in every room. Tindark swung the reel around so it was in front of him and walked normally. To a look from Gell, he said, "The device contains a battery and electric motor. It is controlled by sensors and a computer, so I don't have to do anything. This whole contraption has been stored here since the beginnings of terraforming. It is intended for use if the repeaters fail. The repeaters have stopped and the device works fine. Resilience does have its advantages."

Eltis met him outside. "I did not expect you to be attacked personally," she said. "Sure, it is a way of increasing the intensity of a message, but I doubt your government is going to respond. People in governments try to push their advantages unless the people in them are very primitive, which yours' are not. Allying with us is more of an advantage to them than ignoring us.

"We will have to let the police act. I am sure that eventually they will catch the people they think kidnapped you. Please testify at the trial. You will be an 'alien sentient.' I know you have diplomatic immunity, but please disregard that and textify anyhow. You will have to prove you are sentient, which is to say, you will have to take a Turing Test. That is straightforward enough. There is no reason you cannot take the test and testify, is there?"

"No reason to stop me," said Gell, "so long as it does not prevent me from leaving to go back to Ulterius. Indeed, I am looking forward to experiencing your courts."

"Most likely," said Eltis, "the trial will take place long before you need to go back. If for some reason it doesn't, we will give you the test and take your testimony before hand. So you will experience a part of our legal system and go back as well. But my hunch is that soon we will find those the police think are responsible. We will use a trial to gain knowledge and make the judgement and you will be around for it."

The police computers continued their analyses of body movements. They studied all the current images. At first, they had nine suspects, five for one perpetrator and four for the other. If the prosecutors had detained them all, the majority would have been innocent. However, after more observation and analysis, the computers reduced the num-

ber until each perpetrator matched a single suspect. Those two were arrested.

When reborn into an inorganic substrate, an investigating AI can read a mind — that happened with Airlent; but it takes two years to grow or regrow an organic body. Regardless whether the mind itself resides within an inorganic substrate or an organic substrate, an organic human body takes two years.

However, atomic replicators can create another body immediately. That is how people back themselves up, but the new body is the same age as the old. (No one had pointed out that to Gell, although he had the information. Neither Gell nor any other tree tortoise acted or spoke in a way that suggested they understood.)

The data from a recorded and replicated person provided the information needed to create an inorganic substrate. Unfortunately, that meant a duplicate, since the original replication, presumably organic, meant recording, which involved freezing. The duplicate with the inorganic mind could be questioned while asleep. That way, he or she would not learn about death. However, suppose the investigating AI read the sleeping duplicate's mind and found innocence? What if the awake person did not want to have his or her duplicate killed?

The consequence was that for most, a trial used older, less good technology that occasionally made mistakes. However, if the person was sentenced to die temporarily, as was usual for a serious crime, a sleeping inorganic duplicate was checked immediately and then killed. A convicted criminal lost the right to stop the process, although before dying, a sentenced person was asked what to do in case a mistake was discovered: did he or she want to continue in his or her current body or be reborn into a two dozen year old body in two years?

In went without saying that another purpose of a trial was to convince everyone not only that justice had been done but that justice was seen to have been done.

A presumption that individuals could not decide for themselves was a presumption that they were neither adult nor responsible. While a good many Melians felt that others would go along with what ever their society decided for minor beliefs, they also thought that big beliefs and the actions they invoked would be considered. Unfamiliar actions would not be done accidentally. Kidnapping had to be planned.

"As for crime itself," Eltis said to Gell, "Melior has few crimes and fewer criminals. That is partly because we are a self-selected group, partly because most have been reborn, and partly because assemblers have made material desires irrelevant. Also addiction is seen as a medical problem, a way to commit suicide. It is not a criminal issue. The reborn do not become addicted anyhow, although they can commit suicide, which is not illegal.

"Nonetheless, a few do not accept the restrictions put on the actions of themselves by others. They have not accepted the morality of society, the legitimacy of thinking beyond themselves. Those are the crooks. We try to prevent crooked action and when that fails, reform the person. When reform fails, we need to deter.

"For serious crime, like your kidnapping, we may invoke a combination of deterrence and reform. We try to deter those who do not heed morality and we attempt to reform those we fail to deter.

"Attempts to reform take us little time. Essentially, we try to explain why others restrict your actions. We can explain such restrictions, like the illegality of your imposing too much of a burden on your ecology or the illegality of your preventing anyone else from walking around freely.

"For example, kidnapping is clearly wrong. On the other hand, hurting the environment may not appear wrong to people who don't see the bad immediately. But the long term consequences are like kidnapping: a damaged ecology hurts you.

"Arbitrary restrictions cannot be justified. On Earth you often had to obey others whom you had no part in selecting, not even indirectly. Crooks, whether they were in or out of government, would force you to transfer resources to them. They would steal wealth from you, whether it be material wealth or social wealth. Crooks in government often stole in a disguised fashion. That way, you could not readily determine what went where. For example, government crooks might cause you to support a cut back in research or to support an enthusiast who teaches superstition.

"Besides reform, we deter. A convicted criminal loses his or her life until reborn. Sometimes it only makes sense to rebirth an earlier data packet. Perhaps the earlier identity is more accepting of restrictions. The crook then loses the private memory of the time from when that data packet was made to the time of rebirth.

"Strangely, no one has yet complained that such a loss is only temporary, not permanent, as it was. In any event, death satisfies others' atavistic desire for revenge."

"Tree tortoises are staid," said Gell. "Or at least, they don't get caught breaking laws or seldom do. I don't think they violate them very often. For generations, our governments have been wise. They have not promulgated irrational or unenforceable laws and they have not lied.

"Consequently, we don't have many police. Indeed, they spend most of their time crewing ambulances and looking for dangers, like the possibility of fire."

Among the tree tortoises, policing had taken on many responsibilities. It was more informative to refer to them as members of a protective bureaucracy. Then, Gell thought of Leestel's mother. She looked differ-

ent but was not unlike his own. 'That women is definitively protective!' he thought.

Eltis shifted topics. "How significant do you consider this attack?" she asked.

"Insignificant," said Gell. "I am sure that we will eventually hear some tree tortoises say that we should attack humans. Doubtless, they will be a small faction. As you said, 'it is better to ally than to ignore.' "

"Yes," said Eltis. "What should our two species do? There is no force that can impose on one or other of us. Neither can kill all of the other, but a side can cause damage."

She stopped for a moment. "Let's exchange hostages. We won't call them hostages. We will call them tourists. They will be tourists. Humans visit your Jovian; tree tortoises visit our terrestrial planet. Those will be the hostages. Like every successful political action, tourism fills several desires at once: our mutual need for hostages, satisfaction of curiosity, increased interspecies understanding, having two species in the same system . . .

"Your Jovian has such a huge gravitational field, human information should be radioed rather than carried, especially on the way up. We also use radio for virtual presence on Tegmar, except that we should transfer human minds into tree tortoise robots entirely. The speed-of-light delay is too long to do otherwise. Moreover, full transfers produce hostages; virtual presences do not. We don't have to transfer much more than memories. That can be done for all the reborn. It cannot be done for the first born, but we don't have any children on Ulterius yet. We will solve that problem when the time comes."

Eltis did not point out that Melians had figured out how to revive frozen children, just as they knew how to revive adults. Indeed, the same techniques were used. Bodies were frozen to still their atoms. Otherwise, thermal motion would prevent recording. Melians could transport children or adults; they could make copies. They could replace an original that was destroyed. All this was part of, but hidden in the huge collection of knowledge that Gell possessed. Indeed, Adkel had explained when he first talked with Moel; and Gell had listened. But he forgot and did not remember that he knew.

"After a visit to your Jovian, a human memory will be radioed back up and merged with the original. That way, we won't create unwanted duplicates. Most of the humans will be in organic minds, which cannot be slowed. But we can put them to sleep, so those above the planet don't become bored."

Eltis presumed that humans would travel across the system and orbit the Jovian. In the end they did not do that; they went all the way from Ulterius to Nebber by radio, like tree tortoises in the reverse direction. Otherwise, she described their actions accurately.

"Tree tortoise tourists," she said, "will radio themselves into humanoid robot bodies on Ulterius. They will be radioed off the Jovian in the first place. Perhaps the transmission will go directly to Ulterius, perhaps not. It does not matter. While humans do travel around the system in biological bodies, I cannot see space craft with the thick walls that your pressures require. Moreover, just as humans stick with tradition, I assume that tree tortoises will also. Consequently, I cannot imagine that most will want to shift to inorganic substrates as you have.

"Either side could duplicate and duplicates could live comfortably. But both sides will have access on their own planets to tourists from the other species. Either side could, if need be, make those tourists miserable. That is the deterrence. One side or the other could go crazy, but with obvious hostages, neither side is likely to, not officially. I fear that individuals and small groups will ignore this sort of arrangement or not recognize it. We will have to live with that and expect it. However, by being careful, we in government can prevent much damage."

Gell nodded. He was becoming excellent with non-verbal, human responses. "I think that is good," he said. "Let me consider it first, however."

The kidnappers' trial did convict them. It was quick and soon. Gell passed his Turing test easily and gave his testimony. The convicted kidnappers lost their rights and an AI read the mind of duplicates. The minds disclosed the two had been inspired by Seegraev Wilson, although he had nothing directly to do with them. Because the Melians attached so much importance to individuals, they did not accuse Wilson: he could say anything he wanted, so long as he did not act illegally. His listeners would decide whether he made sense.

Chapter 21

As far as Gell was concerned, the big change that resulted from the attack was his loss of anonymity during walks. He did not think he would be attacked again, but to be safer, and to prevent anyone thinking he was foolish if he were attacked, he walked with the robot that Airlent Irtak had given him.

He looked human, but the robot did not. It could be recognized easily. Then computers could analyse pictures of every human-looking entity near it and identify him. Indeed, they could analyse pictures of every human. They always had been able to do that. Every reborn human had always been able to receive a radio message when that happened, but none had cared. Now they did.

The humanoid robot made it easier. Even though computers were everywhere, few were embedded in devices that looked somewhat human, like the robot. He was noticed; humans on their own identified its connection to Gell, and then they looked for him. None needed computers.

Gell thought of producing several identical looking robots. He could only be in the vicinity of one. But that would not succeed with computers, only with some humans; and in any case, he did not need the extra robots. He did not create them. He had been anonymous before; anonymity was no longer necessary.

Humans recognized him and then ignored him or sometimes they greeted him with the phrase 'Mister Envoy,' nodded at him, and let him go. The greetings were intended to convey friendship. However, 'Mister Envoy' came as four syllables. Gell's own proper and honorable name had only one. Evidently, according to the books Gell studied, and now, according to his experience, the humans on Melior treated one and two syllable names as intimate and preferred more syllables for more formal occasions. Only those who understood tree tortoise culture and who tried to be fully diplomatic called him Gell.

Gell had learned about cable cars from Leestel and decided he liked them. He could look down, even if he was not at the height of a tall tower. In a cable car, he traveled to an art museum that had replicates of originals on Earth as well as Melian works. It was the same one to which Djem went when he first came, but Gell did not know that.

The museum computer pointed to the information about the paintings and sculptures that Gell already possessed but had not recognized. He also pointed out that AIs produced a few of the more recent paintings with a color range that was liked both by humans who saw less than an octave from red to violet and and by those who saw more widely.

Since Gell's mind was embedded in an inorganic substrate, the museum computer said that the added modules he would recommend would

widen his visual range, rather than overlay it as would be necessary in adapting a sentient with a mind embedded in an organic substrate.

Gell enjoyed the thought of seeing a wider visual range. He had hated his experience in the pumping station. When he pulled out of the human body, effectively he saw less than a regular human because he could not see the high frequency colors, the blue end of the spectrum and he could not see his normal infrared because the shielding was so effective. This would be different. He would be able to see all the colors. The museum computer gave him a pair of add-on modules that were designed for humans with inorganic minds.

One module stuck to the skin to the left of Gell's left eye and the other stuck to the right of his right eye. Each module adjusted to the color and temperature of the skin under it and was about the size of the last joint of a human little finger. Gell saw several strangers with them, too. They were hard to see. Others did not notice or pretended not to notice.

Gell found he could switch between the AIs sensorium and the human. The AIs, at least the painters, not only kept the high frequency blues that the tree tortoises did not have, but saw the near ultraviolet, too. Their lower frequency vision went below tree tortoises. That was not confusing to Gell. It was like his viewing low frequency radio during his interstellar transit.

However, the painters saw each individual color in five bands, not three as did most tree tortoises and humans. That took a moment to accept. Each color looked more distinct. If computers in the add-on modules had not told him their names, Gell would have been overwhelmed. And then he almost laughed: not only did the non-traditional color names presume a base twelve numerical system, they also presumed an arbitrary time unit from a different planet: the names were built from frequencies.

Afterwards, human sight felt tame.

A sculpture of a child included the smell of a friendly forest. Gell could not figure out how the forest got the connotation of friendly or why that smell reminded him of his youth as a tree tortoise. It was aimed towards humans. Leaving aside those unanswered questions, he remembered that scent comes from molecules in the air. Unlike the light with which he saw paintings and which comes from elsewhere, scent runs out. Gell considered its continued production a good side effect of replication. Molecular assemblers replaced the molecules of smells.

The change was limited by ability or custom. Gell wasn't sure which. Even though tree tortoises had assemblers longer than humans, no one who sculpted used them. Most humans did not, either. The paintings were visual; most sculpture was just tactile and visual.

That evening, Gell described the museum to Djem and Leestel. Leestel was more enthusiastic than Djem. "That is the one we saw years ago." Looking at Djem, she said, "We should go again." Turning to Gell she asked, "Do you want to go again, too? We could make a party of it. I know," Leestel said, "we can view everything in our heads as if we were there, but still, I like physically moving."

'Humans are irrational that way,' thought Gell, 'but it is better socially.' He wondered how much of the desire was installed by the computers on rebirth. Would it be necessary to impose the same on tree tortoises after many more were reborn?

Gell kept speaking. "On a very different topic," he said, "I finally noticed the obvious."

Djem looked at him with what Gell understood as respect. "It is hard to see the obvious. Our habits are to pass that by and concentrate on the unusual. After all, we live day in and day out with the obvious. Children help grownups perceive, but Melior has few children. Duplicates, of course, are no better than those who made them. What did you notice?"

Gell said, "People on my home planet and on Melior speak only one language. Of course, the two groups speak different languages, but each group depends on just one. I can see tree tortoises being monolingual, but not humans. After all, the Melians who left Earth grew up speaking another language. Yet people here do not speak one language at home and another in public."

"I only speak one language; I grew up here,' said Leestel.

Djem interrupted. "She, we all, speak the local version of Lojban, spelled L O J B A N and pronounced L O ZH B AH N."

Looking at Leestel, Gell said, "Your parents grew up with another language."

"That's right," said Leestel, "and my memory tells me I know it. I could speak it! I never realized that. However, Lojban is better! I suspect that people who came wanted to join together in solidarity, which is why they chose our 'official' language. Moreover, since it was put into their heads by computers before rebirth, no one had to struggle to learn it. Finally, and happily, it turned out to be a good language. Excellence is enough reason."

Gell nodded his head. He found that motion helpful when he was going to speak differently. Also, on this topic, he felt it better to quote someone who might be considered an authority. "According an old time human linguist whom I just read, 'speaking two or more languages is the natural way of life for three-quarters of the human race.' I found that surprising.

"As I said, at home we speak one language. Years ago, before unification, we tree tortoises may have spoken many languages; no one knows. Time hid all our understanding. Very few tree tortoises go into

linguistics and none have found anything definitive. There are no literary references to people speaking another language, no strange writings. For the longest time, we have spoken only one language.

"The data you humans gave us and that Zill is taking home not only include information about the human 'natural way of life', they include reference grammars, dictionaries, writings, and more for many languages. It is amazing. Like plants and animals, a vast number of languages went extinct during the 20th and 21st centuries. Fortunately, you humans caught some languages before they died.

"I intend to tell our people at home about multiple languages — radio will take more than twice the time Zill has left to travel, but no one may have noticed by the time my message gets there; and if someone has, no matter."

On their way to the art museum for a second time, Gell noticed that all the buildings were built from blocks of stone about twice the size of a human head. He was seeing more of the obvious. He asked about the stone.

"Yes," said both Leestel and Djem simultaneously. They looked at each other and Leestel spoke alone. "Robots cut blocks nearby and construct buildings. Everything could be made by assemblers but isn't, but walls and roofs are. Stone is strong and the blocks are carved to fit together well. Well, mostly stone is strong. Very occasionally they carry hidden weakness, but that is so rare we don't worry about it. It is hard on the people who get hurt though, those who have not backed up recently. They lose private memory." She thought of a bridge collapse she had investigated before Djem came.

Djem said only, "Weak stone is rare. No building has collapsed since I came from Earth." He realized the bridge was not a building and corrected himself, "No stone structure has collapsed since that bridge and that was before I arrived." Leestel nodded.

Gell realized that Djem did not speak as much as he might. Perhaps he was too humble? That would not help someone like himself, a lone leader. The trait might be suitable for an Envoy.

Gell spoke again. "I see many people but no humanoid robots. Why is that? I would expect more people with their minds in inorganic substrates to go into humanoid robot bodies since they have stronger hands and even wider sensoriums than reborn people."

Leestel answered, "Organically-bodied humans accept, but don't like humanoid robot bodies. They are not quite the same. Reborn organic bodies are good enough. Most people, and there are not many, who have embedded themselves into inorganic substrates locate themselves in organic human bodies, like yours, mine, and Djem's."

"I did not know what I was going into," said Gell. "I presumed, without thinking, that it was going to be a humanoid robot body."

"Had you done that," said Leestel, "you could not have investigated us humans anonymously. It also permitted you to get kidnapped, since we spied on you from a distance and could not get help to you quickly."

Returning to the topic of construction, Djem said, "Floors are wood." His speaking disconfirmed Gell's notion, but not by much. He could well think it was safer to talk about construction than kidnapping, although Leestel, who was as much a diplomat as Djem, spoke about everything.

Djem kept on speaking. "Thick wooden beams carry floorboards. Construction wood comes from trees that grow quickly. Interestingly, no human, AI or otherwise, wants to wait for an oak to mature naturally. That is more of the obvious.

"Incidentally, room plaster reflects infrared. That way organic humans feel their own radiation bounced back from walls rather than air that might be chilly. This ensures their comfort. You will see plaster inside most rooms even though it would be trivial to make a different wall covering that does the same. We humans are strange."

"No stranger than tree tortoises," said Gell. "In particular, we like caves; they remind us of childhood safety."

Chapter 22

Rill had done a perfectly good job while Gell was gone. However, as far as Gell could see after returning, Rill had not been tested; there had been no serious problems. Part of the time, Rill had slowed.

Moel had not slowed; she had spent more days at full speed than any other tree tortoise. She was older than any other tree tortoise. She studied with Tuppak, whom she liked, and watched her fast growing ecologies develop. They were called 'fast growing' but in fact, by every tree tortoise or human standard, they were still very slow. Her inorganic mind had all the data Tuppak had; but she had not thought about the problems as long.

When her home planet told her about their fast growth, Moel was able to replicate the process. It was a little, but not much different from hers, which ultimately came from the humans.

"That is a problem with software development, too," Tuppak said. He had not slowed or stopped either.

"What? How are they comparable?" Moel asked. "For security," Tuppak said, "two different groups developed software for the same purpose. Unfortunately, they often created much the same programs since their purposes were the same. In the case of software, the blame was put on schools; the argument was that programmers had learned more or less the same. Here is an example of two different species solving the same problem, albeit not software. Their procedures are nearly the same."

A message from his home government waited for Gell. It said they had received both his and the human transmissions from Melior, as well as those from Ulterius. The message praised him. It said that he had done well. But there was no guaranteeing that whoever followed him would be able to introduce suitable changes in the short space of a generation. So the next government would have to adopt human practice.

It would be very different than the home government. Gell's home government had spent a long time making the decision. More than one generation had lived and died. At first the government had intended that Gell and people like him act like home planet governors on a distant tree. Governors made their own decisions about the local place, but deferred bigger issues to the center. Now the government realized that would not be possible.

The colonists' council would have power. One part would represent trees. Another part would represent individuals. The last required explanation.

"It goes without saying," said the home government document, "that we tree tortoises tend to look towards the trees of our births and not

towards new organizations. From a governmental point of view, that attribute has succeeded well. Change has been slow and acceptable.

"However, everyone who is distant must depend on the new. The old is too far away. Also, we need to speed up change yet still keep it acceptable.

"Fortunately, eccentrics become interstellar colonists and a good portion of them are adaptable. We need to encourage them. Many will, of course, stick with whatever new organization they first join; but not everyone. The latter cannot depend on their previous organizations defending them after they have left and joined another. So a branch of government must concern itself with and base itself on such individuals.

"We also need reversion for those who live indefinitely. Otherwise you will continue governor without stop, Rill will always be your number two, and the colonists' council will never gain power. So after the first large number of rebirths, you will cease being governor. Let that be when the first of our migrants are due to be reborn. Although rebirth and reversion will be will be few years later than would be the case otherwise, it will be a good time to institute reversion and to change the form of government. Besides, the time between now and then will will enable us to send the data for a body and let people become accustomed to the notions."

Gell thought of more changes that computers should add to the reborn. He talked by radio with Aglar, since no tree tortoise in the Ulterian system had as yet been reborn into an organic body.

No organic bodies could be force-grown before the data arrived. Interstellar radio lacked the bandwidth for transmitting that data in any reasonable time. It could only transmit information about the differences between two instances, which is how humans were able to start growing a particular body before the arrival of its occupant. Space ships carried large hunks of data from star to star more rapidly than radio, even though radio waves were considerably quicker.

Aglar understood Gell immediately: how to limit tree tortoise population. "On Earth, good eating and bad eating adjusted the populations of non-human animals and pre-industrial humans within a generation or so. For example, a drought meant less food, which meant that young women came to their age of menarche later, which meant that fewer babies got born. After humans invented industry, many obtained their food from farther away. Local disasters hurt less."

"On Earth," Gell said, "Djem not only set up schools to teach people better, he released stocks of local food and arranged for imports of more."

"You can live off stocks for only a few years," said Aglar. "Nobody stores enough to last for grosses of years. That is how long a severe drought lasts." He was thinking as an organic human. "The solutions

are to grow smarter and to import. Nowadays, of course, we can replicate atomically and assemble more food with energy gathered from the sun. We can do that more efficiently than plants can gather energy. If we were not worried about killing the ecology or killing ourselves, we could support a huge population.

"Only by limiting impacts can we be sure we will protect, preserve, prepare, and provide for the future." The Lojban words that Aglar spoke were not alliterative, but the English words were. Long ago on Earth, Eltis publicized that list. The concerns still applied.

"We enjoy indefinite longevity. That is fine. Nonetheless, we will die eventually. We want or should want our successors to live as well as we.

"On Earth, Djem mostly dealt with problems that came from people who did not care that their children's children died. Or perhaps those people cared. Unfortunately, they did not observe reality and think about it, or their rulers didn't. Besides the four 'Ps', Eltis publicized what in English are her five 'Rs': 'Responsibility and reliability determine reality with reason and rigor.' Those people were irresponsible. They were unreliable. They lived in short-term dreams and condemned those who followed."

"Isn't reality a given?" asked Gell.

"Yes, but you can only discover it when you are responsible and reliable. If you give them up, you can determine an irreality; you can make up illusions. An irreality lacks reason and rigor."

Aglar continued explaining to Gell. "By limiting impacts, we can be sure that mistakes will not propagate over vast reaches of time. Our worlds will be resilient. Yes, we have to transform them first, terraform them for humans. That means inventing and installing a complete living system, an ecology. Initially, they start out simple, relatively speaking. We can handle that. But after a time several times as long as you tree tortoises or we humans have been in this system, life's connections become too complex for us.

"You will do the same on this Jovian and on other Jovians your people settle."

Gell listened. He wanted to nod, but realized that he was not in a human or humanoid body.

"We cannot limit organic human populations by having people feel the density of their nearby population," said Aglar, "because rural people and isolates will gain. Furthermore, we can only count on the most basic and minimal changes. Everything else is too complex.

"So we reduced fertility over all. We made only a small change to the genome; we did not change it much. To create a child, a couple needs more of acts of love than before. The number is an average, of

course. Sometimes a sperm will fertilize an egg in the first instance; sometimes not. Some couples are more likely to bear; others less.

"We dared not overly limit population since we or our successors may need a huge growth at some point. So organic humans still need birth control.

"Fortunately, more opportunity for women and the inability to pass on much status to children, which is perceived as a cost, reduces the number of children desired. Unfortunately, in terms of population although not terms of personal choice, multiple lifetimes mean that women can have children and everything else, too."

Had he been able, Gell would have nodded again. Instead, he clapped his forefins together in slow and quiet strokes.

He was beginning to see the impacts of indefinite longevity — even though he had been in an inorganic substrate for years and had been able to duplicate himself, he had not thought through the larger implications.

Aglar spoke more. "So far, at least, population growth has stayed low and humans have little impact. The organic human population could expand quite a bit safely or reduce itself some.

"I would recommend your rebirths follow the same pattern, that reborn tree tortoises and any persons born of them be less fertile than they were. You will need to control your birth rate, too, like humans. But you have civilized a whole planet much longer than we humans, so you can handle births."

Gell agreed again.

"The major issue that I have is how far to publicize the action. We have not tried to keep it secret but we have not drawn people's attention to it either. So some people who should know what we are doing don't. An individual can provide only a limited amount of attention, so giving more attention to this means giving less attention to something else."

"We treat births," said Gell, "as social events. That means everyone local hears of planning. 'Everyone local' includes the tree tortoise placed locally by the central government. That person, who is a local civil servant with dramatic but traditional powers, will respond to central government directives and tell people to have more or fewer children over the next generation. A very long time ago, local people influenced local civil servants. They wanted more children."

"Tree tortoises are like humans," said Aglar. "No species starts with large numbers or starts able to cause global damage. So it makes sense for each to want to produce more. If humans were less successful, they could not cause so much damage. But then, of course, we would not be here."

"However," said Gell, not swerving from his course, "the central government responded fiercely to local influences that countered it. Civil servants fear crossing it; they feared then and they fear now. Consequently, we tree tortoises never formed a tradition that would lead to excessive numbers of people for the planet."

Chapter 23

e aliens at home had experimented with fast growth genes that turned on and off by themselves and found that method failed. (Tuppak noticed that the aliens in the Ulterius system still referred to the aliens in the Xi Bootis system as the 'aliens at home.' They had not yet decided that the Ulterius system was home.)

The extra resources taken by quickly growing bacteria meant that those species rapidly went extinct. Regular, slow growth bacteria survived. Only when experimenters provided lavishly could the fast growth predominate. Then, of course, they took over.

In nature, slow growth bacteria predominated on the edge between living and non-living. Moel did not expect that. "I would have thought that this dead Jovian had enough organic molecules and the like to provide," she said to Tuppak. "After all, our fast growth entities grow quickly in tests."

"Various genes," Tuppak said, "need not only to tell the bacterium to metabolize more quickly, but also tell it how to get the extra metabolites. There are enough molecules but a bacterium has to know how to eat them. If it does not know how to get extras, it cannot metabolize more quickly.

"On the other side," he continued, speaking like a tree tortoise, not a human, "if bacteria did metabolize more quickly and the genes did not turn off, we would always have fast growth. No complex entities could develop because they would die too soon. That is why your people did not put in genes which told how to find the extras, only how to grow more quickly. They wanted the entities to stop growing quickly after a spurt. That was sensible of them! That was a smart experiment.

"After a few generations turned off — more than a few, but after many generations of bacteria, taking what we consider a short time — existing fast growth genes vanish because they are an extra load. That will happen even with large and complex entities; after all, those that are not reborn start small. However, their generations take much longer."

"That is not true," said Moel. "Genomes fill up with junk."

"You are partially right," said Tuppak. "To clean up the genomes of slow growing entities may well take longer than our stars have been shining. The extras are not fatal, although they do reduce survival rates a little.

"In any case, our successful fast growth entities do have genes that tell them where to obtain all the additional food they need. They also depend on a chemical that is not natural, which we can stop giving."

Chapter 24

Gerlintem came to the Ulterius system as a dead data packet. He awoke on the Jovian planet in an organic, tree tortoise body. Like the humans, he needed to practice to connect his nerves right. Unlike the humans, he adjusted quickly.

A tree tortoise who had been reborn earlier helped him and a good number of others all at the same time. Gerlintem followed orders carefully and exactly. He seemed to see, hear, smell, feel, and taste better. His helper assured him that was no 'seeming'; he really was more sensitive. "It is,' the tree tortoise said, "another advantage of being reborn." From Gerlintem's point of view, he had fallen asleep and woke up better.

He found he could think in the humans' two numerical systems, a base ten and a base twelve. Gerlintem could convert from either of those numerical systems to his own. He could think in the Melior language, which was very odd. The language only made sense if you pretended you were human.

Still, those improvements did not surprise him. However, he was amazed to discover that he was now a part of a radio network. Data came to him as memories. He was warned that the radio network did not yet cover the whole planet. Indeed, it did not cover all parts of the seven trees on which people settled. Only the main sections had radio. To him, that coverage made sense. Every Jovian is big. Even assemblers could not construct enough nodes all at once.

Since he did not consider numbers, it did not occur to him that the assemblers had more than enough time to make radio nodes. The lack of coverage kept city tree tortoises from learning to desire fewer neighbors. The empty spaces were ready for new migrants, like those who would arrive in a dozen or so years on Zill's space ship.

When radio covered the whole planet, he was told he would notice speed-of-light delays when accessing unusual data. The most commonly accessed data would come from close by, but ordinary people often looked for the unusual. If that data were stored distantly, it would be delayed. "You may not think the data is unusual," said his nurse, "but the computer data bases will. Most of the time you won't look for anything the computer thinks is unusual. However, occasionally you will. You will sense that memory is hard to get; nothing more." Gerlintem did not pay much attention to probability, which he did not like. He remembered more clearly the useless statement that an unusual memory would come slowly. He expected that.

The nurse went on, "Humans refer to infrequent, rare memories as the 'long tail.' The most common are frequent. For the longest time, humans did not understand the importance of the infrequent." The tree tortoise did not explain what humans meant by the phrase the 'long tail'

since obtaining understanding would force Gerlintem and the others to learn more about humans.

The interstellar space ship Gerlintem came on had been slowed by the central star, the Ulterian sun, traveled out to its Jovian, and swung into orbit around it. The dead data packets and all the other data were duplicated. A copy was sent down to the surface of the Jovian and tree tortoise bodies force-grown.

Only robots quickened immediately. They started growing the first set of bodies. Each instance took six terrestrial years. In the new system, Gerlintem stayed dead for twelve terrestrial years, almost two complete orbits of his home Jovian.

Gerlintem wondered which planet's year to use. Even though the central star was brighter, the planet orbited farther out than home and the radiation received from the star slightly less. This Jovian's year was considerably longer than his original. He noticed that the humans always referred to their original year even though the human migrants came from Melior, which had a different, slightly shorter year. He did not like either the Earthly or the Melian year; they were too short. So was the human Ulterian year.

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Although the planet's population was now nearly as large as the human population on Melior and would become larger once Zill arrived with more colonists, Gell realized he had done almost nothing except follow recommended procedures. Others on the planet told him he had done an excellent job.

At the same time on Ulterius, Leestel did reach the top of her Interior and Foreign Ministry. Unfortunately, her dreams did not match reality. Firstly, she was the only person in the Ministry. She had been right in her description so many years before: the capital city was no more than a single 'neighborhood'. The population of Ulterius was too low for anything else. Secondly, she lacked problems. Either they were prevented by smart robots or they were solved by people close to them. Thirdly, reversion meant she would have reached the top on Melior, a more populated planet with a true Ministry that had dramatic problems. Reversion did not exist when she first went to Ulterius, but it did now.

Having noted the population long ago and having imagined the consequences of a very small one, Djem was not surprised. In addition, he expected Leestel to act. He was not disappointed: Leestel insisted that they again visit Gell and Moel on the system's Jovian. As she said, she could always be called back to Ulterius.

Leestel and Djem referred to the system's Jovian, Nebber. Tree tortoises referred to it by a word that humans in human form could not pronounce, although they could when they wore tree tortoise robot bodies, which is what Leestel and Djem radioed themselves into.

They expected to meet Moel and Gell as they swam out of a tree tortoise hospital in robot bodies. The hospital had become a transportation node.

In the hospital, Djem noticed that many more were in an organic than inorganic body and that everyone who was not a non-sentient robot wore clothes.

Tree tortoises who could wait six years preferred organic bodies, even when their minds were embedded in inorganic substrates. Organic bodies conveyed emotion better than inorganic bodies. Like the equivalent human bodies, organic tree tortoise bodies could continue even when empty. Human visitors stayed in robot bodies.

Clothes were tight and streamlined; flaps covered pocket openings. Openings were always towards the front of a swimming tree tortoise and they had flaps over them; pockets did not swell unexpectedly. Even though a tree tortoise could see his or her top, pockets were always on the clothing's bottom.

As a practical matter, a tree tortoise wore a tube with openings for eye and ear stalks, breathing holes, and middle fins. The various sizes measured only length. Every tube had folds on its top on each side of a central seam. The folds followed streamlines and could be taken in or let out depending on the width of the tree tortoise. In the old days, belts controlled width; now the technology was based on natural burs, just as on Earth or Melior. The seam buttoned. Every bit of clothing had a seam on top. Tree tortoises did not use zippers for clothes even though they had them. Djem did not understand why, except that buttons were an old and traditional technology. Buttons and pockets only stretched as far as forefins could reach without bending. Beyond that distance, clothing grew loose.

Government people also wore crisscrossing sashes, both those tree tortoises who worked for the central government, like Gell, and those who worked for trees. Sashes or baldrics fit towards the front of the body and never crossed pockets. Their ends joined above the seam. To stay tight, newer sashes depended on elastic. Older sashes depended on sewing.

As Leestel and Djem left the hospital, Moel appeared but not Gell. Moel looked worried. "Gell has disappeared!" she said. Then a cop in the local protector bureaucracy appeared. "Our number one has been murdered; I mean the head of the police, not the governor. His name was Veltom." He did not display as much concern as Moel, but he was clearly distressed.

Since all the migrant tree tortoises lived in places that smart robots and assemblers had recently built or modified, the protector bureaucracy had little to inspect or discover. Or rather, they had as much to inspect as planned, but little to discover. Worse, for the bureaucrats, those who migrated were less likely to commit crimes than those on the original world. They were self-selected.

On the original world, there were four senior and many junior tree tortoises who decided who would be permitted to migrate and who would not. They expected less demand for police on the new planet and sent fewer of them. But even fewer were needed than came. Too many were sent. It was a straightforward mistake. One consequence was that they performed more inspections than strictly necessary.

Belgom was the tree tortoise in charge of Veltom's murder investigation. Before the killing, he had been number two among the police. Ordinarily, he would not have looked into murder. However, this was important. He told Moel, Leestel, and Djem that there were only five people who could possibly have murdered Veltom.

"We are going to investigate it at the same time we look for the governor," he said. Djem noted that he did not suggest that Gell had been murdered at the same time, although that thought occurred to everyone.

The murder victim had two syllables in his name. He was fairly senior. Perhaps because his wife had died, Veltom had migrated. On the home planet, police with only two syllables in their names ended their names with OM. Since none wanted to change names, they kept that tradition on the new planet. Like the other tree tortoises, Veltom had been surprised to find himself waking in a young body and welcomed it. He thought of it as being another reason to support the tree tortoise central government.

A rookie named Relnopvikbed discovered Veltom's body. Deltergem, the head of a house that had just been inspected, asked Relnopvikbed to open his far room's door. Deltergem could not open it. He thought that strange. Only the police had been into the room recently.

Relnopvikbed came with a robot who removed the door hinges, a task that took considerable care. In contrast to most human hinges, tree tortoise hinges were fully flexible. In addition, they covered more of a door's edge than most human door hinges. Like human hinges, tree tortoise hinges could be separated from a door. Fortunately, unlike human hinges, bolts went through the frame so the door could be opened from the outside without destroying it; the door itself opened inwards.

When the robot disconnected the last hinge, the door slowly swung open in the reverse of what it usually did. Its lock did not keep the door shut. Veltom's body floated out behind it. With no trouble the robot caught both the floating door and body, but Relnopvikbed nearly

gagged. Never before had a murdered body come at him so unexpectedly. Fortunately for him, his training held. He began to appreciate its simulations, even if they were in classes.

More experienced tree tortoises understood immediately that Veltom's body had been compressed against the door. That answered one question, why the door swung open, but created another, how had the murderer escaped the room? It only had the one door.

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Gerlintem did not like humans. They were not tree tortoises. They had got to this system sooner than his species; that was true. But they could find interior, little planets more easily than tree tortoises could find Jovians with a strong magnetic field. Rockets succeeded in getting the humans off their planets but would fail from any Jovian. The tree tortoises needed Jovians with strong magnetic fields.

The structures in orbit around this new Jovian were not that big. That contrasted to the space station in the planetoid belt where Moel and Tuppak had worked.

Although Gerlintem could read and write and do arithmetic — he had always done well on exams — he failed to understand the consequences of numbers. In effect, for all his excellence at arithmetic, he was innumerate. In particular, he failed to see that although the total mass of planetoids within the Jovian's orbit was small compared to planets, just the smaller rocks provided more than enough mass for huge human and tree tortoise populations combined.

Not understanding, he came to hate humans. He decided they would take interplanetary resources needed by tree tortoises. From his point of view, the humans were dangerous. He felt that a conflict had to occur. He thought that long term cooperation was impossible.

He knew that tree tortoises could not vanquish humans. If they fought as species, the two would damage each other. Even if his side attacked first, many would die in the counter. He would want revenge if humans killed most of his people; he figured humans would want the same if their people were killed. There was no way to avoid that. But maybe, he thought, each side could go its own way, tree tortoises on systems with the proper Jovians and humans on systems with the proper small, close-in planets with low pressure atmospheres touching solid surfaces.

Gerlintem knew he was expected to be loyal to Gell. Most tree tortoises in this system were. But Gerlintem came both from a different tree and from a different faction. As far as he was concerned, Gell had joined the enemy. He argued that 'cooperation is better than conflict.' Gell made deals with the humans. Gerlintem did not think that in

the long run humans would hold to them. As far as Gerlintem was concerned, Gell was engaging in treason to his species.

Gerlintem wanted to force the humans in the Ulterius system to go elsewhere. To persuade them, he intended to kill them. If necessary, he intended to kill them again and again. He was confident that sooner or later they would go to another system. In it, they would be reborn. He was pleased that they would be; although he did not recognize them as 'us', he did see them as sapient. So long as they did not bother him, they could be reborn and live.

There were not that many humans in the system, fewer than a half-twelfth the number of tree tortoises. Still, that was too many. How to kill them? Without an assembler, he could not make conventional weapons. He might be able to free one from its tree tortoise guards, but before being destroyed, he would have too little time to manufacture enough weapons. He had not thought about such constraints before. An inorganic human assembler would fail too. He would not be able to produce conventional weapons fast enough. That left him with one solution, organic replicators compatible to humans: organic human-biology assemblers. He would have to create a lethal bacterium, pass it to one human, have it grow and reduplicate, and have that human pass it on to other humans before the first human died.

It was not going to be easy. However, Gerlintem was accustomed to working in a team. That was fortunate, he felt. He did not have to learn human biology or how to transfer a bacterium to a human; he simply had to recruit a tree tortoise who knew and who would not give him away. It was not truly simple, but it was doable.

Gerlintem knew how to gain followers; he would tell a good story, one that enabled him to offer the appreciation needed for self-respect. The hard part was finding a person who did not gain enough respect in mainstream society, was competent, had the right skills, was willing to act, and would not give him away.

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At first, everyone looked at pictures of Veltom's murder scene. Gell stayed disappeared.

Belgom connected to the murder investigation's householder, Deltergem, and asked him to explain what could be seen. "I know you have been through this before, but I want you to explain again, in your own words." Djem nodded to himself. No only was Belgom seeking new detail, he was making sure that Deltergem's story contained no major inconsistencies; Djem expected minor ones if the fellow was truthful.

Veltom's body showed he had been stabbed and cut with a non-serrated knife blade about an eighth of a meter long. That matched a

kitchen knife. Nothing else was readily available to tree tortoises. That is why investigators suggested the knife was from a kitchen. Deltergem reported that part of the story, saying that he himself could not tell. "The body was very bloody."

Further, according to the evidence, the murderer had tried to move or further cut the corpse which was stuck in front of the door. But he or she had never done enough to open the door. The investigators tried to find more evidence but found none; the killer knew what they did.

Deltergem explained that the room was for guests. It was the farthest in the row, with one door and one window. It did not connect to a deeper cavern, unlike two other rooms.

Djem decided that the door looked as if it were designed for humans. Even though tree tortoise swimmers were more likely to rotate themselves and could push or pull less than humans, the door had a knob. Normally, tree tortoises turned it and pushed or pulled the door open, unconsciously using their fins to prevent themselves from rotating in the opposite direction.

Doors stuck occasionally. Since tree tortoises were weaker than humans, hinges could be unscrewed from either side. More than humans, tree tortoises understood that the purpose of security was merely and always to delay. If you could not steal technically, you could steal socially. No one could do anything more, although a person might pretend.

Fortunately, trees had almost no thieves on them, so a removable door did not matter.

On the other side, to use the tree tortoise expression, a window was always open to the atmosphere, although in a city it came with a metal grate to protect its room from the outside. Air flowed between the metal bars.

A room required little protection, Djem decided, but tree tortoises kept old habits long after they ceased being useful.

Originally, Djem learned from his computer memory, gratings were hard, stick-like bushes with thorns that grew in front of cave entrances. They repelled unfriendly animals. However, they opened at the smell of any animal that provided it with solid waste for several days. That was how they obtained fertilizer. The bushes lived symbiotically.

According to legend, this was all discovered by an early tree tortoise whose name was Birn. He also discovered, so it was said, that not all stick-like bushes had thorns. Moreover, these other sticks could be made into arrows. Although nothing could shoot a long distance because of air resistance, arrows traveled further than most animals suspected. Hunters killed more.

In the early days, a tree tortoise grabbed sticks when they died. Later, a tree tortoise attached living sticks to a stone or bush with thin

vine or string. When those sticks died, they broke off their anchors and floated away but were never lost.

According to the pictures taken as evidence, the room had horizontal bars attached to heavy but movable pedestals. A tree tortoise grabbed the horizontal bar with his or her feet and held position. Deltergem never bothered to mention them.

The pictures also showed two beds in the room, an empty table edging two walls, and a writing panel. Veltom's body had jammed between the table and the door. Deltergem simply listed the big pieces of furniture: table, beds, writing panel. Neither Djem nor Leestel had been in a private bedroom yet, although the information provided to the humans by the tree tortoises told them what to expect.

Each bed consisted of parallel, lengthwise poles with a frame of perpendicular straps that could be pulled over a tree tortoise back. The frame kept a sleeping tree tortoise from drifting to the window. Or at least, Djem thought, it meant that both sides of its brain could sleep deeply at the same time. In the wild, one side stayed awake or partially awake to watch for predators and to keep position and altitude.

The surface of the table paralleled the gravitational field. Heavy objects would not slide off it.

Djem wondered why tree tortoises did not use floors more. Then he looked at Moel. She was horizontal. Indeed, looking at his memories, he had hardly ever seen a tree tortoise tipped nose down more than a little, not enough to place or pick up anything from a floor. Evidently, tree tortoises preferred to be horizontal or close to it. Tirn's innovation, his military galleys, required both that he thought of the unexpected and that others became vertical rowers. The innovation was dramatic.

The table hugged a wall; it was not very deep. Tree tortoises could swim up to it with the lower half of their bodies below its edge. They could place or pick up an item with forefins. They could stay horizontal.

Shelves fit above the table. They held tall printed books that tree tortoises liked as well as various odds and ends, mostly statues that did not float away. Djem discovered that such tree tortoise statues had been carved from soft stone; that is why they did not float. He presumed that these specific ones had been recorded on the original Jovian and replicated on this Jovian. They did not look new enough to have been carved here. He did not ask Deltergem since the murder did not involve pounding.

The writing panel was not parallel to the surface of the Jovian, since that would be inconvenient to see. It was not perpendicular to it either, since that would be inconvenient for pens which might be dropped away from its surface and which sink. Paper could float away.

Instead, the writing desk was at an angle half way between. It had a raised bottom edge which caught dropped pens. Unused pens sat on it. They were put there.

Paper was kept in place by weights attached to ribbons. The weights told Djem either that the writing desk was itself old or that it used an old method. Metal springs and magnets could keep paper in place, too. Then he learned that weights on ribbons, the old fashioned technique, was still most common.

Unencumbered walls had pictures hung on them, good paintings. Djem smiled. A project of his had really worked: smart, but non-sentient, human computers had looked at tree tortoise domestic pictures. Most such paintings were no better than human pictures of that sort. The human computers suggested tree tortoise pictures that were better and that their assemblers could replicate.

Then Djem frowned. Would this project discourage tree tortoise painters, most of whom were not as good as the best? Cheap reproduction came with disadvantages as well as advantages. On the other side, tree tortoise painters could emulate humans on Melior. They could create paintings that fit their society. In that case, easy reproduction was an advantage, since a torn or dirty painting could readily be replaced.

The room had only the one door and one window. The keys to their locks hung on a rack with other keys, including the key to the front door. That rack sat in a corner but hardly filled it. In any case, no one would look. The rack did not replace a picture.

"That is where we store our spare keys," said the householder. "I don't expect guests to steal them."

The five who could have murdered Veltom were Telmernimmil and Heldripdrimtun, both rookies, and Pulterpun, Mentegmen, and Kilbenvin, who had years of seniority among them. Djem did not think it was professional to tell him the names of the suspects before making them public, but neither he nor Leestel were going to speak out. He suspected Moel would not either.

"If your student police live in barracks," said Leestel, "neither Telmernimmil nor Heldripdrimtun will have ready and unwatched access to kitchen knives. They will eat in a cafeteria with other rookies. They won't have ready and unwatched access to any other kinds of knife that have blades long enough, either."

"Speaking of rookies," Djem said to Moel, "if you want above all to ensure loyalty, and tree tortoise rookie training is at all like human training, you will have your novices live together. Then they will form friendships with people of their cohort. In addition they will be exposed to one sergeant continually.

"Training has two different goals. One is technical knowledge. For example, rookies must learn how to inspect properly. That becomes

harder and harder as robots carry out more and more inspections. Smart but non-sentient robots can remember the technical knowledge that people forget. Your rookies will have been reborn, so computers can insert that knowledge; but eventually, you will have the normally born who don't have that kind of knowledge. Regular schools can pass on the kind of technical knowledge that your bureaucracy requires.

"The other goal is loyalty. When rookies graduate, they end up with more power than ordinary tree tortoises. As a group, the people in your protective services have enough power to fight a civil war. Besides doing inspections and what not, they have weapons and know how to use them. A smart government maintains loyalty."

Belgom protested. "We have not done anything at all!"

"Have you changed old procedures?" asked Djem.

"No," said Belgom,, "not that I know of. We have not done anything. I don't know anything about influencing groups."

"No individual need know," said Djem. "In this case, individuals don't count, only groups. In any organization, such as your government, the more successful groups survive and the less successful don't. You need only be part of a successful country, which you are, and not change old procedures. You do not need to know anything.

"Indeed, whoever started need only follow his own preferences and habits, like having tough but ultimately helpful sergeants."

"No one asks to know too much," said Belgom.

"That is not the issue," said Djem. "It is not what people know, it is what they seek. A government lasts longer when no one seeks too much. I guess that is what you might have meant when you spoke of asking for too much." He paused for a moment. "That is the key, seeking too much," he said. "People who as you say are 'farther away from the center' cannot seek much since a part of their surplus goes to people closer to the center."

Djem stopped speaking for a moment again and Belgom waited. "On Earth, in pre-industrial times in particular, there was never much surplus. Chimneys poured smoke into the rooms they were supposed to heat and stayed inefficient until someone invented a 'throat.' Earlier, in many areas, food grains were planted too close together. Grain was wasted.

"Those to whom surplus is transferred, people closer to the center, cannot ask for too much either. If they do, or in human history *when* they do, they or their children or their children's children are overthrown.

"However that may be," continued Djem, "traditionally, governments have two goals. One is to transmit technical knowledge. The other is to ensure loyalty. For generations, schools, even bad schools,

have taught. As it happens, generalized loyalty to a society can go along with other loyalties.

"The difference comes with loyalty to a specific group that a government thinks could be dangerous but wants to have on its side. For that kind of loyalty, government agents break individuals' previous bonds with their family and clan. In your case, they must break bonds to the tree in which they grew up. If a government cannot destroy bonds, it must make them weaker.

"When rookie training strives towards loyalty, at least among humans, a sergeant will show understanding as well as toughness. He will act as the agent of government, even though most likely, he does not think of himself that way. He will make rookies suffer, he will shout at them, make them do whatever they consider unpleasant. That shows social power."

Belgom interrupted at that comment, "What do you mean, 'social power?' Ultimately, rookies are subject to coercion, to physical power."

"'Physical power' involves a group of loyal thugs; you don't call them thugs, you call them 'constables' or whatever. My point is they are loyal to the organization on which the sergeant depends. Since he is in the same organization, the sergeant has social power."

Djem went on, "At the same time, the sergeant will provide help to rookies. He will be sympathetic when someone's parent dies. That provides another way to show social power. The whole procedure does not work well with what you call eccentrics, but the right people thrive."

"You are cynical," said Belgom.

"No, I am not cynical," Djem protested. "I am a hopeful realist," he said. "And, of course, I am speaking of humans, not tree tortoises. However, I suspect that however different the two species look, their minds operate more or less the same."

Leestel broke in. "Instead of talking about 'breaking previous social bonds,'" she said, "you could talk about 'substituting new social bonds.' That would convey the same notion.

"You could say," she continued, "that not only must rookies learn technical skills, they must learn to work for everyone, not just people in their tree."

"I agree with that," said Belgom.

"That does not convey exactly what I want to say," said Djem. "For example, if rookie training fails, trainees may not go back to their previous loyalties; they may stay loyal to their cohort, to others who joined at the same time, and be corrupt with them. The notion of loyalty is important; so is the notion that rookies might fail to learn to work for everyone.

"Only good training will encourage loyalty to the organization as a whole. (We hope the organization operates as the government wishes.) Incidentally, in an organization, good training results mainly from picking the right people to become sergeants; it means enforcing prohibitions against irrational abuse.

"At least that is how it is among humans," he finished.

"What does this have to do with murder?" asked Belgom.

"We are trying to discover whether these rookies lived with other students like them," said Leestel. "Djem is suggesting that they must."

"Rookies live in barracks," said Belgom.

"If those barracks are at all like human barracks," said Leestel, "neither will have ready and unwatched access to kitchen knives." She was repeating herself but finally had confirmation of where trainees lived.

"Where was Telmernimmil inspecting?" she asked.

"Telmernimmil was practicing some distance away. Veltom expected him to find a loose housing on an incandescent; earlier, Pulterpun, a much more experienced inspector, had carefully and secretly loosened it."

"So there are two reasons that Telmernimmil should not be suspected, lack of access to a knife and lack of access to Deltergem's house," said Leestel.

"That's correct," said Belgom. "What about Heldripdrimtun?" asked Leestel.

"Heldripdrimtun is not quite as much a beginner as Telmernimmil," said Belgom. "However, he also lives in barracks.

"He was inspecting the same house as Veltom, so he had that opportunity. He had already studied evidence, so presumably he know what to avoid leaving behind. I don't know how he, or any murderer for that matter, got out of the room."

Belgom continued speaking. "However, like Telmernimmil, he could not readily obtain an unwatched kitchen knife or any other kind of knife. Not long ago we inspected the rookies thoroughly. It was a regular inspection. We discourage rookies from keeping anything we don't provide." He looked at Djem. "I guess you would say we are forcing loyalty. In any event, I doubt any rookie could hide a knife successfully during such an inspection. Sergeants, we had three, know every hiding place. Neither Heldripdrimtun nor Telmernimmil have had time to go into our kitchen or to acquire any knives since then."

"In other words," said Leestel, "we have three suspects, not five."

"Yes," said Belgom, "I am thinking this through as we speak."

Djem was quiet.

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Gerlintem knew he could not kill Gell forever. Gell was backed up. But he could be killed for long enough. Death would stop interference. It would confuse everyone else.

Gell was not expecting an attack. He was swimming on his way to see Moel, Leestel, and Djem when another tree tortoise came out of a house, still deserted, in a volume of the tree that did not have radio. The second tree tortoise stabbed Gell with a knife. There was only the one other tree tortoise and no monitoring nearby except for Gell himself.

Gell's organic body died quickly. He stopped being able to move, see, hear, smell, taste, or feel. Had he been fully organic, his mind would have died with his body. But he was not. His inorganic mind kept on.

It was identical to that created for entering the human bodies even though it went into an organic tree tortoise body. Its existence was more an accident than anything else.

When Gell came back from Melior, he had moved from his interstellar space ship to a human body just so he could welcome Djem and Leestel. When Gell transferred the first time to an organic tree tortoise body, assemblers built another inorganic mind, and because they had not been told otherwise, modeled it on the robot that first entered a humanoid body. The exact form was irrelevant to Gell. He simply wanted his mind in an inorganic substrate and it was.

At the moment, Gell's inorganic mind was enclosed in his dead body. In particular, the sensors on its robot body could not see anything. Gell realized that his attacker thought Gell's inorganic mind was embedded in his organic tree tortoise body and unable to leave.

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Earlier, Belgom had said, "Pulterpun could have committed the crime. He knows his business, he could obtain a kitchen knife easily. When revision comes, I expect to see him become my successor.

"However, he is not a suspect; he was investigating a different building and lacked the opportunity."

Belgom ground his teeth together, the tree tortoise equivalent of a human pursing his lips. "That leaves two," he said.

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Gerlintem pushed Gell's dead organic body into a room deep in the tree. Fortunately for Gell, his living inorganic body could detect motion vaguely. Unfortunately, it could not feel motion precisely enough to

reproduce the route. But it gave Gell a hint. He figured the dead organic body would be dumped.

After a period in which Gell's inorganic robot body detected no motion, he decided that his attacker must have left and carefully exited the body. Gell came out into the dark. There was nothing he could see, not in humanly visible light, not in the infrared he could see; there was nothing he could hear. Nonetheless, just in case his attacker heard, Gell did not make any noise. He feared that if he made a sound, it might be carried along tunnels farther than any echo.

Instead, Gell swam away from his dead body. Gell was glad he could swim. Within a short time, he bumped against a wall. His grippers grabbed it easily. It felt like a natural room in the depths of a tree. When he was stopped and anchored, he felt a little bit of air motion; it was not what Gell would call a wind. In the old days, he would not have noticed. However, because of his experience on the surfaces of Ulterius and Melior, he had learned to perceive weaker currents than before.

Since it was day, the outside was warming up, transferring its heat inside, and the denser air was going outside. Gell needed to move with his back to the air current. That he could do.

He stayed attached to a wall. Although Gell could swim faster than he could crawl, if the attacker came again and Gell were swimming in the middle of a room, he might fail to find and hide in a wall crevice soon enough. That was critical. He kept track of the time.

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At the meeting that Gell did not reach, Belgom said, "Mentegmen had the opportunity; he was in the same set of rooms. Also, he lives in a family; he could hide a kitchen knife. He could have had the means. However, he lacks motive. As far as I can determine, he is satisfied with his position."

"That leaves one left," said Leestel. Belgom thought it perfectly normal that she should state the obvious.

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As he in his robot body crawled out, Gell thought of this tree. It was young compared to the tree by which he had grown. Being young, it was fairly low and hot. People did not wear too much clothing. They did not do so much with their walls either.

Bushes grew on trees' top surface. Humans called them 'tree tortoise sea weeds.' They had long, wide leaves that rose up and waved very gently in the slowly moving air. If cut and not corralled, the leaves, really fronds, floated up and away. After they died, they petrified,

even in the damp, and become lighter. In most instances, they stayed attached to their roots or became covered. Mainly, they kept trees from floating lower. These leaves had not yet grown much. That is why the tree was floating low down. Petrified fronds compensated for spills that added weight. Old trees without much spilled on them floated higher. In addition, the bushes had roots that conducted heat, enough conduction for rooms' 'breathing.'

Occasionally, living leaves broke away from their roots and floated up. Usually, a tree survived such a disaster; it was not sunk by the heavy roots. Not enough broke way and the roots were not heavy enough. Very occasionally however, a tree sank too far, everything attached to it burned, the remains sank further, and eventually it all vaporized.

Gell crept through the dark, keeping the weak air current always at his back. Sometimes he lost the breeze altogether, but he knew what direction he had been going. By the third time, he was not much bothered.

It took four times as long to come to a room that was not dark as it took from the time he was attacked until motion stopped. But he got there. The room had been modified from a natural cavern by dumb robots. It did not have any furniture in it, only an incandescent light which stayed on.

Since assemblers had built collectors on this Jovian as well as in space, energy was cheap. They could leave lights on. The light was designed for tree tortoises, but none had come yet.

An incandescent was a wire inside an electrical insulator. A grid around it kept tree tortoises from accidentally getting burned. Because Gell could see what humans considered infrared, the light was much more efficient for him than incandescent light bulbs had been for humans. Human incandescent light bulbs converted much of their input energy to heat, which humans couldn't see. Both tree tortoises and humans could cook with their incandescents, but only tree tortoises made a habit of it. Indeed, humans hardly ever used incandescent light sources any more.

The tree tortoise light source was even redder than sunlight; and that had been reddened by its trip through the Jovian atmosphere. Put another way, the light source produced even more infrared than atmospheric sunlight. Even so, output from the this light fit into Gell's visual sensorium better than the light from a higher temperature incandescent fit into the humans'.

From the lit room, Gell took little time to reach the surface. He was careful lest the attacker return, but pressed on towards his original meeting place. He still gripped solids although he could readily swim in the light.

As he turned a corner on the surface, his radio communicated again. He immediately told every one what had happened — he included a picture of his attacker — backed himself up again, just in case, and was promised a tree tortoise inorganic body while robots grew another organic body.

Almost immediately, police came. "We received your transmission. We worried when you did not arrive at your meeting and started searching. Veltom was murdered. His body was found. We are going to rebirth him, but he has lost all the time he had here. If we wait for another body to grow like his, he will be gone a very long time. I don't know what we are going to do. We think now that Kilbenvin murdered Veltom.

"You are with us! That's good. Based on your description of where your organic body was dumped, we would not have found it for days. Your body's killer should have known that you carried an inorganic mind and tried to destroy it. Every space man has one. If he had not been able to destroy it, and even if you could not have left your organic body, we would have reached it eventually. You could have slowed to avoid the craziness resulting from sensory deprivation."

"Yes," said Gell. "Almost no space men have inorganic minds in second bodies. So, my attacker wouldn't necessarily know I could get out. Probably, he presumed my mind was embedded in my head, as it would be normally, even if it was in an inorganic substrate."

Shortly thereafter, Gell reached Moel, Djem, Leestel, and Belgom. Moel made to push her body against Gell and then realized his mind was in a small, robot body. It was not the same as before.

Gell described the attack. Belgom said, "It might be connected to the murder of Veltom, or it might not." Djem clapped his forefins together in slow and quiet strokes, the equivalent of a human nodding. Sometimes, the obvious should be said.

"Presume they are connected," said Moel, "which is more important? Presume they are disconnected, which is more important?" Then she answered herself. "The governor is more important than the chief of police. I am not saying that the chief of police is unimportant; I am just saying that the governor is more important."

"Veltom's murderer," said Belgom, "had a more complex task than whoever attempted to kill or delay Gell. He had to leave a locked room. If the attempt on the governor were more important, why would that be? I am starting to think that Veltom's murder and Gell's attempted murder or whatever are coincidental."

"Various reasons make sense. Suppose, for example, that one murderer had to stick with the less important target. In any case, it does not matter," said Moel. "In so far as we must choose, we must settle the attempt on the governor first."

She looked at the little robot body that held Gell. "A simple way to reduce your power would be to delay your entrances to physical meetings. Any enemy can do that. But I don't think that was the intent here. There was more to it, I am sure."

"What would be more?" asked Gell. "Almost everything on this planet works automatically. I hardly ever do anything important. I don't have to stop existing. If it were not for the humans, I would have almost nothing to do. It is better to be a spaceman than a governor."

"What about an attack against us humans?" asked Djem.

"An attack against you humans?" Gell turned his robot body towards Djem. He thought for a moment and then turned towards Moel. "What would get them out of the system?" he asked.

Moel answered. "Killing many. They will all be reborn." Djem clapped his forefins together quietly. "However, they will lose experience. Not everyone will have backed up recently." Both Djem and Leestel clapped their forefins together.

"To be successful, an attack on humans has to be biological. That is not simply because I am a biologist. Whoever attacks will lack access to a mechanical assembler. Our assemblers are too well guarded; the humans won't let one go to a tree tortoise."

Moel looked very serious. "No one of us tree tortoises knows about human bio-weapons, but enough is known about human failings to construct a bug that will kill. And although no one can get hold of an inorganic assembler for private use, a public assembler will construct a laboratory that will work with human-compatible organisms. Organic, biological organisms will replicate.

"Such a lab will be off planet. Your attacker or a colleague will have to convert to a robot body in space. For technical help an attacker could convert a dead data packet that came from home, but no one would be confident of that instance. An attacker would be more confident of someone who had already shifted over. A tree tortoise can be radioed off the planet, put into an inorganic substrate, and work on an anti-human weapon."

Moel did not know that the humans could make atom by atom copies of intelligent living beings; they had solved the problem of reviving those frozen so cold that the copying mechanism could discover where the atoms were. No tree tortoise had done that yet. They could only revive simple organisms.

"That means a person must disappear from here," Moel said, referring to the Jovian planet they were on. "It takes nearly one of our original years to grow a body for an adult; he could not be duplicated yet.

"The police should look for recent disappearances," she said.

"If any have disappeared, he or she might be another murder victim," said Belgom.

"That is true," said Moel, "but if he or she is a biologist, we should look for a biological laboratory that is off the planet and recently built."

Gell clapped his forefins together and Belgom gave orders to look for a tree tortoise who had disappeared. Such a disappearance was found rapidly since an employer had already reported what was to it, indeed, to everyone, a very unusual event.

The tree tortoise who disappeared was not Gell's attacker. He was a disgruntled and not terribly good tree tortoise biologist called Debgrindervin. His name had four syllables.

"Debgrindervin is good enough," said Moel. "He will have to learn human biology, but that is relatively easy if you already have a grounding in our biology, as he does. You simplify when you have one goal, such as killing. As I said, he is good enough."

Belgom decided to look for a lab.

Finding the bio-weapon's tree tortoise lab was both easier and harder than Moel anticipated. It was easier in that robots kept records of what they constructed. In the planetoid belt, they had built a human biology laboratory recently. It was harder in that magnetospheric plasma engines and stealth moved the lab among rocks where it hid.

Because the lab could not be found, Moel asked Djem and Leestel, "Can you humans help? I don't know how much time we have."

Djem told Aglar Ivden, who was in orbit. Djem did not use the common network. Instead he depended on a single, point-to-point infrared communicator that could only connect when Aglar's orbit crossed over his position on the planet below.

Belgom helped Djem by having the transmitter and receiver built secretly. It was easy for the tree tortoises; they just had to make sure the infrared was below the frequency, at a longer wavelength, than any tree tortoise in orbit might monitor or see. Aglar always watched the planet in infrared. He saw the spot of light from Djem's signal, had no trouble decoding it, and was able to talk. It took him almost no time at all.

Aglar told Adkel who told the other relevant humans. Aglar and Adkel did not use the common network. Aglar transmitted in microwave to Adkel who monitored a little used frequency 'just in case.' After all, doing that did not cost him anything. And, for once, monitoring proved useful. Adkel told the rest, those who were on his station and those who could receive communications safely.

No one trusted the common network; they feared someone in it had been corrupted. After a very short time, taking into account Aglar's

orbit and speed-of-light delays, humans said their assemblers could join with the tree tortoises'.

Like the tree tortoise assemblers, the human assemblers would produce small, stealthed, sensor-bearing, robot-guided interplanetary space ships to search in the nooks and crannies of every planetoid in the volume.

Moreover, they asked the tree tortoises to stop human vehicles with their interstellar particle beam generators. By pushing space ships and their payloads with generators that were close to Ulterius, the humans could start them moving fast, but they would not stop until they came upon a star or an interstellar particle beam.

Because they could also be used as weapons, Earth only had weak particle beam generators nearby. However, they would have served well enough. Earth's drivers pushed vehicles to the Kuiper Belt more quickly than the sun. In the Solar System, the powerful, interstellar particle beam generators lived in the Kuiper Belt, where they were too far from Earth to be a danger. Those generators stopped vehicles from Earth and launched them interstellar. Ulterius had not worried that an enemy would grab them so it built close.

The tree tortoise particle beam generators were in an orbit in the planetoid belt close to many rocks. That was convenient. Since their orbit had a shorter period, they were not by the Jovian. By luck, they were close to where everyone assumed the lab hid. Six dozen terrestrial years before, the two positions had been on opposite sides of the sun. The planet itself was a quarter away around its orbit from them, but that distance was very nearly irrelevant. It was crossed by radio.

It went without saying that the 'rocks,' the planetoids, in which the bio-weapon's lab hid were so far apart that the laboratory could only hide in a nook on one. It was big enough so that even if stealthed, it would already have been seen had it tried to orbit on its own. None of the planetoid belts in any habitable system were so thick that anything could hide among them. The surfaces of three planetoids had to be searched; the total was large, but not huge.

Both species' assemblers, the humans' and the aliens', built more of themselves. They duplicated and reduplicated. Then they produced other items more quickly than one or the other could alone. They built many investigators.

At the same time, Djem and Leestel radioed themselves into humanoid robot bodies that one of the assemblers built. They had enjoyed embedding their inorganic minds in a tree tortoise robot bodies, but after human assemblers built a human vehicle, they returned to humanoid bodies. The spaceship did not carry a living organic garden although it had the data packets for one.

Rather than enter a tree tortoise robot body or even a humanoid robot body, Gell transferred to an interplanetary space ship with manipulators as well as sensors. He felt at home doing that. Djem could have done the same, but instead he chose a humanoid robot body that would ride a space ship. Gell thought that odd. He dismissed the characteristic as resulting from a human planet with its low surface pressure, low gravity, and humans' consequent ability to put fully organic beings into space.

Djem and Leestel's actions took longer than Gell's: their assemblers spent time making their robot bodies and a bigger space ship than Gell's. But the assemblers did not take much longer. The two humans used an atomic assembler for the computers and other items which required atomic precision, and a spray-droplet assembler for the rest. The spray-droplet assembler was faster than the atomic assembler since its drops were so much bigger than atoms.

"This technology is dangerous," said Djem to Gell. "It can be used illegitimately." The two were close enough to use point-to-point radio without speed-of-light delays. It was a conversation. A few others listened. In a sense, Gell, Djem, and the others were creating a new net.

"Suppose you want to track an enemy," said Djem, "and you are sufficiently rich to bribe a cop or politician. Bribery presupposes costly and fungible goods which you can buy. Since robots can remember who you are, you can't buy location, status, or attention unless that is permitted. Think of a place that is like Earth without von Neumann machines, not like here or Melior. In addition you must hide what you buy by telling computers to ignore you at the appropriate times, again like Earth. That means paying more bribes.

"On Earth, many of our cops are corruptible; so are many politicians; so are others who have access. If you are rich, you can track your enemy. When you hire someone to specify a number of individuals, you can track all of them. You can track another group. For example, an ethnic or sectarian leader can follow his group's competitors as well as his personal enemies.

"Some innocents are tracked, too. They are known in the jargon as 'false positives.'" said Djem. "Too many false positives push up the cost. But a few innocents do not bother the corrupt. Unfortunately corruption plus modern technology means that many more innocents are killed or have their lives ruined than are hurt by courts. In turn, that means that governments lose their abilities to protect people and lose legitimacy.

"On Melior and its political descendants corruption is contained. Fewer innocents are hurt. Leaders gain more success by cooperating than by competing. That is an advantage for Melior."

"You speak of corruption as a kind of competition," said Gell. "Certainly the briber and the person bribed must cooperate on their illegal act."

"Yes," said Djem, "they must cooperate to do wrong; but at the same time, the briber transfers resources to the bribed, an act which only seems compensated because the briber cannot do what he or she wants justly. When just action becomes possible, you see that the weaker competes against whoever is more powerful socially."

Gell remembered that Djem was the Envoy from Earth. He was still the only person to have lived on Earth relatively recently and also come to Melior and Ulterius. The Melian migrants had ancient memories.

"Even though we have had recorders and assemblers longer than humans, devices that could replicate themselves, we have not had a problem with excessive corruption," said Gell, "at least, not that I have heard of. Perhaps few thought to replicate sensors; maybe most did not know how to be corrupt. Perhaps members of the central government do not need additional material goods; regardless, they certainly have kept strong control. But now they and everyone else will study humans and learn about recorders, assemblers, and corruption. That is a disadvantage of our meeting you."

"Yes, corruption is bad, as is our teaching it to you," said Djem. "Fortunately, we humans have techniques for resisting excessive corruption. When applied, the techniques succeed. Unfortunately, not every ruling group applies them and not every society has a culture that is against the poorer being forced to transfer their resources to the richer unjustly."

"I don't think we will have social troubles with anti-corruption drives," said Gell, "so long as they fit the existing relationship between trees and the central government.

"At one time," he said, "a central government could only control transport and trade among trees, not within them. Trees themselves were too expensive and too difficult to search."

"Not with replicators assembling computers and sensors," said Djem.

"That is true of the present. In the past, trees enjoyed a great deal of autonomy. Cities became variegated. Individuals could hide on a tree. Others protected them so long as they acted only against outsiders, which is to say, those who did not grow up on the tree.

"Regardless, since punishment reduced revenue, our central government came against any sort of punishment. Tolerance became traditional."

"How do you deal," asked Djem, "with the problem that a tree can track its enemy so long as it has an assembler to make sensors?"

"To discover their enemies," said Gell grimly, "people on trees do not need sensors. They already know.

"More to the point," he kept on talking while they waited for the results of the search, "how do we prevent richer individuals from redefining who is 'us?' Advances in technology stop trees from being the relevant unit. Why shouldn't one group exclude others? That is the tree tortoise equivalent of your question: changing conceptions of 'us.' That is definitely corruption. A few aberrant individuals could cause enormous trouble."

Gell thought about it for a while, then said, "We need outsiders making up what you would call an 'anti-corruption task force.' It would look at people within trees. The central government and other trees could fail to support such a task force because they care mostly about trees as a whole, even if some people in them exclude others. They want to think about large groups, not about individuals. On the other side, none would oppose an anti-corruption task force, either. A small amount of tax money could be spent. That would come in addition to the small amounts that are spent for traditional anti-corruption efforts. I think the extra will be enough."

Like his comments on multiple languages, Gell planned to inform people at home about his thoughts. If people there had devised a solution before his message reached his home planet, that would be fine; if not, he hoped to provoke.

His remarks about multiple languages had reignited debate about the tree tortoise past even though they arrived long after Zill's space ship. No tree tortoise had paid attention to a characteristic of humans, which is that they still had many languages. His message pointed that out.

"I hope you are right," said Djem. "Meanwhile, our sensors have detected an anomaly on the second rock . . . we are getting a closer look now . . . that looks like a lab!"

All the investigators were small. In addition, they were passive; they depended on natural sources of gamma ray, X-ray, ultraviolet, visible, infrared, and radio radiation. They did not give away themselves; they were not active, except in their transmissions, which were direct. By being small, stealthed, and passive, they were less likely to be discovered.

Fortunately for Gell, Djem, and the rest, and unfortunately for Debgrindervin, he expected to hide the lab. It was stealthed, but like humans, he depended more on 'security through obscurity.' Of course that failed.

Once the investigators had discovered the bio-weapon lab, it was straightforward to determine that nothing had as yet left, which meant the weapon had not been spread. A short time after, assemblers built

enough devices. Again stealthed, they transported themselves to the other side of the planetoid — both Djem and Gell hoped the sensors and computers for the bio-weapon lab would ignore anything that was not able to sense the lab because of the huge mass of the planetoid. One device crawled slowly on the planetoid's surface. It was the only one to see the lab.

The two collaborators thought it less likely that the lab would detect a device stealthed against the surface of the planetoid rather than in a close or intercepting orbit. In orbit, an attacker might inadvertently move a star behind it. Naturally, like the smaller investigators, such a device would project stars in all their frequencies, radio, infrared, visible, ultraviolet, X-ray, and gamma ray. It would not occlude them, since that would be an obvious give-away.

Still, both Gell and Djem worried lest the lab's sensors be sensitive enough. They worried lest sensors be hidden on other planetoids so a free floating device could not simply stealth itself in one direction. They worried lest enemy sensors be free floating and stealthed.

Gell and Djem had already taken into account the possibility that Gell's attacker monitored normal communications. He would bribe another tree tortoise in the network or provide that person with a believed promise, like getting rid of the humans. That is why Gell's and Djem's communications were always point-to-point. No one could break encryption. But what was still called 'traffic' could be analysed. Gell and Djem's enemies would become concerned if Gell was supposed to be still missing, yet Djem talked for a long time with someone in Gell's office

Gell and Djem's surface attacker beamed back signals to an antenna that barely poked over a crater face. It was on another crawler that mostly hid. The second crawler retransmitted the signal to yet another. The second crawler was stealthed in all directions, but could not be as well hidden in the directions it transmitted. Nothing was transmitted off the planetoid until it was a good distance away from the lab. The second crawler's antenna intercepted all of the first attacker's transmission, as did its equivalent on the attacker. The attacker hid the second crawler's antenna from the lab.

Besides carrying sensors and radio, the crawlers depended on manipulators they used to move.

The attacker crept closer to the bio-weapon lab. No evidence existed that the crawler had been detected. Besides passive senses on the part of the lab, like eyes, the attacker perceived a variety of active signals, including sonar that came through the planetoid. It was stealthed against all of them. It pretended not to exist.

A smart defense would initially try to avoid providing evidence that it had detected an attack. If it were successful at doing that, it could find out more.

So if the attacking device had been sentient, like Gell, Moel, Leestel, Djem, or Aglar, it would have been concerned. But it was not sentient. Only Gell, Moel, Djem, Leestel, and Aglar worried. They followed the specific form of attack most probable of success; it was not guaranteed to succeed.

The crawling attacker touched the building, not near an antenna, lest a very slight change in its signal be noticed. Nothing came through the walls. They were well shielded. Still the attacker did not gain any evidence of being caught. It recorded and transmitted everything and then started, gently and secretly, to bore into the wall.

The humans possessed more sneaky technology than the tree tortoises. They had developed it. The tree tortoises had the human information but did not know where to look or even to look. Tree tortoises like Gell could only imagine the simplest possibilities, such as how to reach another tree tortoise when encryption was unbreakable but people in the network might be corrupted.

'The humans have had more experience being bad,' thought Gell, 'than we tree tortoises, although I cannot say that intrinsically they are any worse than we. They have had more opportunity to be bad.'

The human-designed attacking crawler hid itself from the currents and signals traveling the wall and transmitted them all. At the same time, it separated those signals that were designed for defence from signals designed to carry other information.

From the second set of signals, after a considerable wait, the crawler found that the bio-weapon was intended to survive for a short time in human air and designed in humans to create sniffles. That information came from mutation specifications. The original had been harmless.

Survival in air and the sniffles in humans would enable the virus to spread. Those features were new. Another new feature killed humans, but not right away; it blocked energy transfers in a cell. Creating the delay caused more difficulties for Debgrindervin than anything else. He wanted a bug that spread and duplicated in other humans before killing them.

If they noticed the virus, humans could mount two defenses: one triggered a human immune system to be more sensitive ahead of time. That was a vaccine. The second added to an existing immune system by helping counter bio-weapon viruses. That was an antiviral.

Debgrindervin hoped that humans would ignore sniffles. He feared they would pay attention to sneezes. If the humans only suffered sniffles and ignored them, his virus could spread. Then, he hoped, his virus would kill almost all the humans. He knew that after the first death, humans would notice the virus and try to counter it.

As far as Djem was concerned, the attacker had provided enough information for countering. The rest would be gravy, to use an old metaphor.

He told Gell, who was relieved. Nonetheless, Gell said, "Let's go for the gravy!" Moel and Aglar agreed. Djem was already persuaded. He nodded. The others saw and understood, even though at that time only Leestel of the others wore a humanoid body. Aglar did not.

Djem said, "Let's bring up more attackers. One might be enough but we cannot be sure. The chance any will be detected is less than before because of signals the first one intercepted."

While six additional robots slowly crawled into place, nothing was done against the lab. They all succeeded in boring into a wall and remaining undetected, at least as far as could be determined from the two kinds of signal traveling in the walls. Djem was fairly confident that those signals contained everything. "The lab is not much of an onion," he said. "I suppose you can count the outer shell and the walls themselves as parts of an onion, but even if so, there are not very many. Unless, it is truly a misdirection, which I doubt, we should not have learned about the weapon. The signals at this level should be those of a harmless, albeit hidden, lab."

Gell's evaluation of the human technology went up another notch. Then he realized he was using a human metaphor! He understood the metaphors of 'going up' rather than going towards the center and of a notch on a stick. An unregenerate tree tortoise might say 'going towards the center another pebble' even when the technology was human.

Tree tortoises had used pebbles to remember counts. They clustered them in groups of four laid out in two columns, like the lobes and fins of a tree tortoise. Except the counts were usually less than two dozen. Gell wondered about the phrase. Why go towards the center 'a pebble' when the distance might be more than one pebble? He did not know the answer and had he been human, he would have shook his head. The thought of shaking a humanoid head reminded him to think about the human technology again.

The crawlers, the stealthed watchers, were not so advanced a tree tortoise could not understand them. 'This technology may not be worse,' Gell thought, 'than having a very advanced sentient detonate your sun; but we have not seen unexplained novae, so they cannot be common. Unfortunately, we are in contact with humans. Tree tortoises will have to learn the technology.' Gell stored those comments. He planned to transmit them to specific offices in the government by Xi Bootis when he again dared to access the common network. He knew that nothing stayed secret in the long term, but he hoped for the short, even when humans provided the underlying information and made it public.

'At least,' Gell thought, 'the humans did not focus anyone's attention on espionage and sabotage. You have to understand humans before seeking out the technologies.' And even though he felt he understood humans, he had not sought it out.

The bio-weapon had not been sent to the humans. The lab not only did not have assemblers, the vats for growing the bio-weapon were too small for reproducing a huge amount. That was an inescapable design flaw. Debgrindervin specified study, which meant smaller vats, not war production. He dared not provide true specifications lest other tree tortoises stop him. The virus reproduced fast enough, but a full vat had to be emptied and that took time.

The tree tortoise assemblers had built interplanetary vehicles so that after enough of the bio-weapon was produced, it could be carried to Ulterius and distributed. The interplanetary vehicles were designed as ore carriers. They were fairly well stealthed, which reduced the chance that human sensors would detect them. If another tree tortoise had noticed the stealthing, Debgrindervin had been prepared to say that he wanted to determine the quality of the human sensors and computers.

However, with the information already collected by the first attacker the humans knew to watch. Stealthed interplanetary vehicles might have passed undetected before. If they came now, the humans would discover them, or rather they would be detected by sensors and humans would be notified by the computers which analysed sensor output. Particle beam projectors would disintegrate unwanted interplanetary vehicles. That was the third human defense, the first an actual attack would meet.

Djem hoped to destroy the lab before it launched even one weapon-carrying interplanetary vehicle.

The seven robots buried in the weapon's lab walls prepared. They were going to try to counter every signal in the system, including those that made up Debgrindervin's mind. In case that form of attack failed, hidden and distant robots prepared mortars to launch stealthed explosive shells. They would destroy the lab physically.

In case the free flying shells were seen and destroyed, other robots set themselves up to come within the purview of sensors on the lab. These robots substituted explosive for electrical circuitry but otherwise massed exactly as much as those which had previously reached the walls. They looked the same. Both Gell and Djem hoped that if necessary, they would reach the walls before detonating. Finally, if all else failed, stealthed emplacements would pop up and destroy known weapons while a third set of robots, armed and stealthed, carried explosive to the lab by yet different routes.

As it turned out, the lab avoided physical destruction. Instead, the seven robots buried in the walls stopped everything. Gell discovered

yet more human technology. He had not realized they could stop all the electronic signals in such a complex and resilient building. Then again he knew; yet again he did not know he already possessed the knowledge. He added that to the comment he was planning to transmit to Xi Bootis.

The humans were dangerous! Had humans been able to slow interstellar space ships before reaching Xi Bootis and prevent their detection, they could have killed everyone on their home planet. Gell thought it fortunate that his government had assemblers build a thick shell of sensors around Xi Bootis. Only fast space ships could hit the planet now.

Mutually assured destruction kept governments rational. Nongovernmental groups were not so rational. Although complications would come from stealing an assembler, building beam projectors secretly, and all the rest, only one group had to do it all. Nonetheless, the recognition that not everyone would die prevented an irrational attack. These groups were not bothered by the prospect of damage to their own species, but they could not expect to kill every opponent. That stopped them. Not even Gerlintem's group tried to attack all the humans; they just wanted to force the humans out of the Ulterius system, to create apartheid.

Nonetheless, Gell felt the truth that his universe was better when none were hurt, at least, when there were more than enough resources for them all. He remembered that 'cooperation is better than conflict.'

The attack on the weapon's lab killed the tree tortoise bio-weapon biologist, Debgrindervin. He had transferred himself from an organic body on the Jovian planet to an inorganic robot in space. He was as open to attack as every other electronic part. Like Gell in his space ship, Debgrindervin embedded himself in the overall matrix. He turned his attention to sensors and manipulators in different parts of the lab. Since nonsentient computers did the dull jobs and warned him of the unusual, he found it unnecessary to have the ability to attend to everything all at once. No sentient did; the organic humans did not; nor did their artificial intelligences.

Only the organic weapon, replicating in vats, continued to live. That would not be for long. Food and energy stopped coming in. Excretory products stopped going out. The attackers planned to destroy the vats twice physically. The first destruction was more for show than anything else. It would tell who ever watched that the physical embodiment of the weapon was gone, although not the information about it. That neither would nor could ever be destroyed.

The second physical destruction would occur when the vats, their contents, and the rest of the lab were disassembled to atoms by a recorder that would pass its physical output to an assembler that would eventually use the atoms as raw material. In the meantime, the assem-

bler would not replicate the lab, but simply sort the atoms by type and weight. Since both the recorder and the assembler required a temperature close to absolute zero, every output would be solid, including elements that would turn into gases without much of a rise in temperature. The lab would turn into bricks.

Before chemicals broke apart the weapon's molecular bonds in the first destruction, the more photogenic action, the humans wanted to see the design of the weapon exactly. The chemical destruction would prevent the recorder from learning the shape of the bio-weapon. As Djem said, "Molecular knowledge will not add to what you and we already know, but the design will show what a relatively untutored biologist thinks is important for killing. We will gain a new understanding of a hostile sentient analysis." Gell noted that Djem did not say 'tree tortoise analysis.' "If someone else, equally ignorant, makes an attack, it may well be somewhat similar."

Djem paused for a moment. "In the future, at the very least, smart computers will check to determine which human sniffles are harmless and which are dangerous — which come from viruses which are intended as stimulants to the immune system, which come from viruses that are accidental, and which viruses could cause harm, whether they be accidental or purposeful, weapons or not. This design query is somewhat different from that; as a practical matter, it suggests to computers what they should look for first. Each incident will require a whole investigation, but that takes time. What we think are the most probable dangers will be investigated first. I bet you never thought this would end up being primarily a public health issue!"

Gell understood that military action was mostly irrelevant. A health danger had to be stopped whether or not it was intended. Funding health equaled funding soldiers. The public health service defended people as did an army.

Since this was an intended attack, he figured the humans would think of this as a military action rather than as a public health action. But a quickly responding public health system could have defended humans even if there had been no warning other than an increase in sniffles. Would the humans or their computers notice the sniffles? The tree tortoise attacker, Debgrindervin, presumed not. Based on what Djem said, he was correct. However, they would now.

Gell thought about it. 'To kill or maim enough people, a biological attack has to infect a huge number. That means either considerable substance, which increases the chance that a part will be discovered, or replication and spreading. Airborne transmission is not the only way to spread a weapon, but it is the quickest.'

He decided that Debgrindervin had been smart. Even with replication, a considerable amount of viral material was required to reach

everyone. Only that Gell's mind lived in a separate, movable body saved the humans from an unexpected attack. He saw his survival as a necessary condition. He did not simply disappear, which would have confused everyone else. He came back. Gell thought the history through. If no attempt had been made against him, no one would have discovered the attack on humans. But an attempt was made on him and he came back. Then Moel's three suggestions formed additional necessary conditions: that the intent was more than a simple attack on the governor, that human biology provided the only feasible weapon, and where to look first.

Together Moel and Gell mulled the action without the humans hearing. "Good will come of this," she said. "How so?" asked Gell.

"Humans now know that our government will cooperate with them as best we can," said Moel.

"According to your report, when you first went to Melior, their president, Eltis, welcomed you and said 'Doubtless we will have political trouble; I am sure we will overcome it.' We didn't intend trouble, but we just completed what humans call a 'trust enhancing step.'"

"You mean . . ." said Gell.

"We warned the humans and acted against our own crooks. We needed help — I think that was good — and together we destroyed an enemy."

"That doesn't mean the humans are always going to trust us."

"No," said Moel, "it doesn't. Fortunately, according to another of your reports from Melior, Tindark implied that what humans see and hear immediately has more impact than what they see and hear less immediately; and this was certainly immediate!

"He was talking about the humans we have met as creating a poor sample. That is doubtless true. They are a poor sample. But here we do the opposite, we convert less into more, we convert the memories of an immediate attack into trust. That is the advantage to us. The advantage to the humans is that they need worry less. They will still worry, but when they trust us, they will worry less."

"That's fine," said Gell. "What about records from assemblers? That is how we discovered an assembler had built the laboratory."

Moel thought about the question. "I am not worried about you transforming records, but am worried about your successors. One of them may misuse those records. Besides making it difficult, so only a few will bother trying, we should make arrangements to publicize misuses."

"What do we do if someone gets into the programming?" asked Gell.

"Set a program to monitor changes in the records. That program cannot be changed," said Moel.

"We cannot set up an unchangeable program; in generations to come, the only way to rid us of it will be to destroy the computers it resides on."

"Then, for verification, require that at least three people, from different trees, access that program in the same short time. This is a good job for a randomly selected jury. It can have more than three people in it. So long as nobody has been appointed to any governmental position in the last two local years and so long as the selection process is truly random, no briber can predict who will be on that jury."

"We don't have juries," said Gell.

"I know," said Moel, "but we will eventually. The humans will corrupt us. Juries are part of a solution. They are not all of it, but they are part of it.

"This will serve as a beginning. Members of a jury will only occasionally have to log in with their own, personal verification. Already, all the reborn have two of the three major items needed: who they are and what they know. No one is ever going to carry a material object, which is the third item, so those two are going to be enough.

"Everyone already has two pass phrases. One of them is for regular access and most don't know it since the connections are automatic. The other is for fully private access. A person chooses it. That is the one we will use. The humans, at least some of them, will know more about various kinds of skulduggery."

"'Man in the middle,' . . ." said Gell.

"Yes," said Moel, "attacks like that."

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Gell, Moel, Djem, and Leestel all radioed themselves back to the central tree. Moel shifted a little robot into her organic body; the others took up robot bodies with small robots in them.

Djem accessed data sources in the hospital that was the receiving place for incoming humans; he learned that the central tree was nearly as large as those on the original; it had grown quickly. However, it was not as thick as the picture of an original, although it did have a rough surface all over, small mountains. Higher hills stood near the center. Visible holes suggested numerous caverns. The leaves of a wide-bladed grass waved gently in the thick air. They could not stay up on their own, so they had to float. To some extent, then, they held the tree up. Djem decided the grass was a 'tree tortoise sea weed'. He did not bother to discover whether or how much metal dust the tree had already turned into nodules. They would weight the tree down, so would roots. Regardless of what young trees could or could not do, metallic nodules did not exist initially. For construction, the very first aerobodies must

have brought metal from orbiting planetoids. Later, assemblers could collect metallic dust while floating free.

Moel had planted seven trees, all of which had grown. Rather than name them 'First' and 'Second' as the humans did their cities, the tree tortoises identified them by letter. The humans ended up having the first and second trees called Aburis and Bylris. Djem thought the ends of each name should have a 'CH' sound, but they had an 'S' or a soft 'Z' sound instead.

The four swam from the hospital to the main police station. Looking at the tree tortoise city as they swam over it, Leestel said, "Assemblers make things you can point at."

"Some kinds of information cannot be pointed at, like language," Gell said. ". . . or love, or status," Leestel said.

"People prefer symbols you can point at," said Djem.

"No, they don't,' said Leestel.

"But they do," said Djem. "They pick an example of love. Painters draw that example. Or photographers take pictures. As far as I can determine, the key is to make representations, whether for sight, sound, or touch.

"Most humans and even more tree tortoises prefer what they can see ocer what they cannot. Think of books, museums. When people cannot look at love, they look at a picture instead. Everyone understands that examples are examples. Fewer than one in six humans go for sharp definitions."

Leestel said, "Are you suggesting that in the old days, before books and illustrations became commonplace, people considered abstractions less?"

"In Europe," said Djem, "during the Middle Ages, churches and cathedrals contained numerous paintings. Most were later destroyed. Priests were taught to point towards those paintings. Even earlier, every culture had dances.

"In one sense, yes: I am saying people had less to consider in the old days; in another sense, no: I am saying that painting, sculptures, dances always existed.

"Pointable notions are fine. We are not discussing them. My question is whether less pointable notions have examples attached to them. As far as I can determine, they always do: painting, dance and sculpture. Painting provided for sight; dance provided for sound and motion; sculpture provided for feel . . .

"Less pointable notions become familiar. The distinction is not between concrete and abstract — even among humans, when you think about it, 'tree' is an abstract notion; you have to point at an instance of a specific species. You can never point towards a 'tree' as such; the

notion is too abstract. The distinction is between familiar and unfamiliar."

"In any case, assemblers cannot make love, attention, or status," said Leestel.

"What about location?" asked Gell.

"The value of location is a consequence," said Leestel.

"I agree," said Djem. "How close our embassies were to the central Melian government: that is example of location.

"The location of the government: that was chosen. Doubtless, the specific location was chosen by a computer, but it was told where on the planet to put the capital city, near the equator as it turned out, in a geologically stable area, and where in the city to put the government buildings. Assemblers built them. They constructed the edifices, they provided the furniture."

His direction of motion turned when he turned his head. Consequently, he fell back and looked at each person ahead of him. Since each tree tortoise could see behind, each could see Djem.

"That is my point," he said. "Assemblers construct; they build what I am calling 'examples'. When what is built consists of government edifices, the location of an embassy conveys status. When the built is for another person, the example shows love."

"What about language?" asked Gell. "You can listen to a word, you can talk about a grammatical construct. But you cannot point at 'language' itself."

"Language is a good notion," said Djem. "It is a good example," he said, moving his whole body backwards and forwards with his middle and back fins, the tree tortoise equivalent of a smile. He started moving again; none of the rest had stopped.

"A language becomes familiar as people listen to words and talk about grammar." Djem had not realized that most people as children listened to sentences rather than words and did not discuss grammar; they learned fine. "An assembler can construct a device that records and plays back spoken words; other people or other smart computers can talk about grammar and you can listen."

"You are saying," said Gell, "that both tree tortoises and humans depend on physical examples for what they think?" He was not sure at all about language although he wondered whether the discussion of grammar came after writing.

"Yes," said Djem, "My sense is that the concepts of concrete and abstract were developed by the one in six or fewer who write about their concerns. They wrote the books. Their samples excluded commonplace notions like love or status that you cannot point to but which everyone

speaks of. My sense is that some of these people imagined their notions are abstract because most people were unfamiliar with them.

"In the early days, for example, hardly anyone knew about electricity, so it had to be unfamiliar. An extension of the metaphor of 'current' gave people the image of a river. That was important, since people already knew about rivers and streams. They flowed from higher to lower."

"So you are saying," said Gell, "that people, humans as well as tree tortoises, applied their existing knowledge of streams to electricity?"

"Yes," said Djem. "Everyone in those days, whether tree tortoise or human, lived in a constant gravitational field — it was felt to be constant; you had to make special measurements to discover otherwise.

"In particular, in a constant gravitational field, equal changes in height lead to equal changes in energy. So voltage became the metaphorical equivalent of height. Mathematically, that works, too. The metaphor is consistent. It is a good metaphor."

"What are the implications of this?" asked Leestel.

"They are political," said Djem.

"It may not be relevant to you, but it is relevant to Earth," diplomatically, he did not mention tree tortoises, "that the polity determines how technology is used. Beliefs and, to a lesser extent, laws are critical. Beliefs are established by the culture, that is to say, by the set of metaphors. Obviously, only some metaphors succeed, but the range of those that do is dramatic."

"Please give an example," said Leestel.

"Suppose you think resources are unbounded, which makes sense when your capabilities are small."

"What do you mean?' asked Leestel.

"Consider moving dirt. Whether you are a tree tortoise or a human, you cannot move much alone with primitive or no tools." Leestel clapped her forefins together in slow and quiet strokes, the tree tortoise equivalent of a human nodding. "That is your experience. You are familiar with your experience. Consequently, you will have a hard time when lots of people, with advanced tools, move a great deal of dirt. On Earth at the beginning of the third millennium, humans began to move about as much dirt as nature. The culture did not have solutions ready. People became aware, but they did not know what to do."

Gell clapped his forefins together. "Tree tortoises primarily act on what happened before they were born. Intended change happens slowly."

"But," said Djem, "unintended change may happen quickly. That is to say, it may happen quickly in planetary terms. Among humans, change often occurred too slowly for the short term."

Moel said, "Rather than concern ourselves with the unfamiliar, let's act promptly on an important and familiar event . . ."

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They swam towards Belgom's room in the central police station, where they had been earlier.

Djem was not sure what to call the station. It wasn't a house. He did not think it should be called a building because it did not stand above the ground. He decided to call it a 'facility.' That word did not suggest it was above ground.

The underground building, the 'facility,' was small. It consisted only of five rows, each with only four rooms. Except the middle row had five rooms. Djem gathered all this as he swam towards its entrance. Like Melior and Ulterius, tree tortoise computers had mapped just about everything and made the information public. Djem used his internal radio to gather the information.

Unlike the others, which were more or less square, the first room was twice as long. It served as a reception area. Besides its front door, which led outside and through which Djem and the rest entered, it had five doors towards its back. The middle door went to long tunnel off which four other rooms branched.

Doors to the left and right of that middle door went through short tunnels to the first rooms of the second and fourth rows. Those two rooms served both as passageways and as common rooms for their rows other rooms. Like back rooms in the middle room, the back rooms of the first, second, fourth and fifth rows each branched off a tunnel. Those tunnels made the facility unlike a family house.

The first and fifth rows were very like the second and fourth except the tunnels to their first rooms were longer.

Belgom said, "For the moment, I am using Veltom's office." It was the first room through the right most door at the back of the reception. Belgom had not introduced anything personal in it. There was nothing of Veltom either. It was not clear whether Belgom had removed such belongings, pictures, or personal wall hangings, or whether Veltom went without. No one asked.

A long, shallow table attached to three walls; shelves above the table carried printed books. From their titles, Djem saw they contained laws to enforce and regulations to follow. Human societies had more written laws, but these looked to be enough.

The room also contained six horizontal bars on pedestals. They surrounded a low table that nonetheless was high enough for display. Evidently, tree tortoise police liked to show pictures and reports to others. They used, or they had used in a previous generation Djem

remembered (how, he was not certain), their equivalent of paper, even though on this planet they could all send images to each other using their internal radios.

In the office, they turned to Veltom's murder. While focusing on the more important attack, they had ignored it. Now, Belgom had to follow it. Gell figured Belgom had the right to be involved, even if he did nothing and Moel was curious. Djem and Leestel expected the murder to teach them about tree tortoises.

Belgom nodded at Leestel. He remembered her earlier analysis. "Only one of my original suspects is left," he said.

"Kilbenvin. He appears innocent. However, like most older tree tortoises, he lives in a family. He could get the means. He was inspecting the same set of rooms as Veltom. He had an opportunity. Did he have a motive? That is the question. That is one question; the other question, which I still have not answered, is how the murderer escaped the room."

Djem turned to Gell. "You said earlier that in tree tortoise cities windows have locked gratings on them to keep out intruders. Is that right?" "Yes," said Gell.

"What are your locks like? Specifically, what is this lock like?" Djem asked. "Some Earthly locks click locked unless you set them to act differently."

Both Gell and Belgom looked surprised. "At home," meaning on the original tree tortoise world, "a lock did nothing if its key was turned in the wrong place," said Gell. "In fact, it did worse than nothing, since you could readily swing the grate open. Locking only succeeded when someone turned the key when the grate was closed."

Belgom clapped his forefins together in slow and quiet strokes. Then he stopped and looked alert. "Assemblers built this place," meaning they built for the tree tortoises on the planet. "Everything is new. The assemblers looked at the most recent design. They randomized keys but otherwise every door and grating lock is the same."

He was learning from external memory. Clearly, it was still a new experience for him even though he had been on this planet for a dozen terrestrial years. He spoke, "Just like on Earth, these new models can set to lock automatically or to stay open. When built, they are set to stay open, since no one knows where keys will be. It is safer to leave a door or window unlocked than have it lock unexpectedly."

He stopped for a moment and focused on the lock on his window. He had not noticed before, but it had a not very visible switch on it. "I bet old timers sought evidence at the scene and they assumed, like me and Gell, that the locks here were the same as those we grew up with at home. They aren't.

"I haven't done any inspections of this sort. I didn't know about locks. Veltom occasionally inspected. He should have learned about

them. Certainly, every inspector would have, but not necessarily those who gathered evidence.

"I bet that nobody recorded the state of the switch in Deltergem's guest room."

Gell clapped his forefins together very quietly.

"Our only pictures of the lock are too fuzzy to tell how it was set," said Belgom. "We will have to look ourselves."

"Will the setting have been changed by the tree tortoise who took the original evidence?" asked Leestel.

"Several technicians searched for evidence," said Belgom. "If they followed procedure, and I am sure they did, they would not have touched anything. They won't have changed the setting."

"Since the evidence was taken, will anyone be likely to have changed the setting?"

Belgom looked happier. "No," he said, "and the room has been marked off limits. It's being monitored by audio and visual sensors. I don't think anyone has looked at the recording, but if someone came in, we should be able to see what he did."

"Or see blank time," said Djem, "or see nothing unusual since his movements were overwritten. How secure are your records from a person who is smart, motivated, and knows more than you do? What is the probability that your sensors and recorder work?"

Belgom looked pained until Leestel asked, "What is the probability that the recording failed or that anyone broke in? Just as there is a risk in doing nothing, there is a risk in acting. A perpetrator might be caught."

"Let's look," said Gell. "We will take new evidence. If the grate is set to lock automatically, and most aren't, . . .", Leestel interrupted. She said, ". . . we can presume either that the householder set it and we should see him on the recording or the householder set it before the murder so he is not recorded or else the crook set it. Those are three possibilities. I suspect the crook would have set it before he first left because no householder would care, so long as the grating locked and he would most likely do that with a key and the grate shut."

"The recording does not show any entries," said Belgom. "I just looked. It does not look like it failed, either. Not only have I looked at the change indicators, which don't show any change except the sun and the clouds, I have run the recording fast and seen only sped up days, nights, and weather."

"Let's look at the scene of the crime," said Moel, who had been floating quietly all this time.

As they went, Djem reflected: 'crime scene' was an old and dramatic term. He was not accustomed to it.

Djem looked around as they swam. All the tree tortoises he saw were healthy. He could not remember seeing any that had not been. So he asked Gell what they did when tree tortoises could not swim. Djem did not see any mass transit or special vehicles for the disabled.

Gell said, "Incompetent tree tortoises are pulled as knights were. Indeed, the technology has hardly changed since before Tirn. Naturally, the beast does not push a spear; neither are armoured."

"I did not think they were,' said Djem.

"Truly disabled people have attendants," said Gell. "Before rebirth, almost everyone became somewhat disabled when they grew old. We had lots of pulling beasts. However, almost everyone died before they become more disabled. We never had many fully disabled.

"Since everyone was reborn recently into young and healthy bodies, we don't have any disabled at the moment except for those who are accidentally injured and taken by ambulance to a hospital. There are a few others who make their own way to a hospital, but they are rare.

"Buses, our mass transit vehicles are streamlined. They look as we do, but are much bigger and have fans instead of fins." Gell looked at Djem. "I bet you don't notice them. In just the past moments, we have passed six, none close by."

Djem stopped suddenly, the tree tortoise response to surprise. He hadn't noticed!

"As on Melior," Gell continued, "people propel themselves to their destination or go to a mass transit stop where they ride the vehicle as close to their destination as they can."

Djem began to swim again and Gell said, "We don't have as thick a mass transit system as humans have on Melior. It is not automatic either. Tree tortoises drive our buses. It goes without saying that we have not required tree tortoise drivers for generations, not since smart, non-sentient computers could substitute. But we still have them."

Most of the time, rooms of a house were controlled by one family. People entered though a main door. However, one room was now the 'scene of a crime'. It was controlled by the police.

At the house, the senior tree tortoise looked at them with some disgruntlement. He wore a young body but managed to look old nonetheless. "When can I get that room back?" he asked. Belgom said, "Soon." The householder looked at Belgom, decided he was not going to get more information, and made the tree tortoise equivalent of a human shrug: he moved his eye and ear stalks to the front and to the back. Somehow that motion conveyed both irritation and resignation. Even Djem noticed, but no one spoke.

The five, not the householder, swam into the guest room. The window grating was set to lock automatically when it swung shut.

"The lock does not operate like an old one. Presuming the recording is good, which seems likely, there are two possibilities," said Leestel,

"First, and I think most likely, the murderer could have found and used the key kept in this room to unlock the grating, kept it open with his knife or equivalent. He could have hung up that key, swam out of the room through the window, took with him whatever he used to keep the grating open, and let the grate swing shut and lock itself." She did not consider that the murderer could have unlocked the window, set the window lock so it did not lock, hung up the key, left the room through the window, changed the lock, and let the grating swing shut.

"Second, the householder might have changed the setting before or after the murder, most likely before. Let's ask him."

They swam out of the room and found the householder again. He was near the entry. Belgom came up to him. "We have a question. The question, even that we asked it, must be kept secret until we act on it. Can you and will you do that?"

"Yes and yes."

"Did you, or anyone you know, set the grate to lock automatically when it swung shut?" asked Belgom.

The householder looked puzzled. "How can that be?" he asked. "I locked all the gratings once, when we moved in. That was the last time I looked at them or touched them."

Belgom answered the rhetorical question, "This is a new planet and the assemblers have installed new-model door and grating locks. Both me and Gell," he pointed at Gell, although it was obvious who he was. Djem nearly laughed. Belgom was covering himself. ". . . when we grew up, you could only lock a grate by turning the key when the grate was closed. You could not set it to work automatically. Now you can." The householder clapped his forefins.

Belgom then looked at Gell, Moel, Djem, and Leestel. "Let's visit Kilbenvin." Djem decided that police procedures were civilized. Rather than a word such as 'investigate,' 'question,' or 'arrest,' Belgom spoke the word 'visit.'

They followed Belgom who headed away from the house back towards the main offices.

Djem never did discover which room served as a jail. All of them headed towards to the second room of the fifth row. "After me, Kilbenvin has the most seniority," said Belgom. "His new room has only one work place in it."

But when they got there, it was empty. The window grating swayed open.

Leestel immediately looked out the window, gasped, and tugged Belgom with a forefin. "Is that one of your people?" she asked, pointing at a tree tortoise with sashes who was swimming away rapidly.

"That's Kilbenvin," said Belgom. "He must have panicked. He should have remained here and bluffed us." Leestel had already started out the window, swimming after him.

"Perhaps he thought we knew more than we did," said Belgom. "In any case, he could have seen us coming; we swam across this view before we got to the front door. I did not think of that." The others swam out the window after him and Leestel.

Leestel passed floating sashes. "Those were Kilbenvin's," said Belgom. He did not sound normal. "Now he will look like every other tree tortoise. I bet he is going to hide."

Leestel, Djem, and Gell were not straining. Gell understood almost immediately. He was third, "You," he said, pointing to Belgom, who was now fourth, "and Moel are pumping an enormous amount of air through your lungs. We, on the other side, are in robot bodies. We are stronger. If you deputise us, we will arrest the miscreant!" Djem noted that Gell, even though he was governor, had to ask Belgom to deputise him. Moreover, he did not think to conduct a citizen's arrest even though it was obvious now that Kilbenvin had committed murder.

Through his internal radio, Djem learned as memory that no tree tortoise had the power of a citizen's arrest. He decided that the central powers wanted to avoid any concentration away from them. Djem also noticed and felt pleased that without thinking Gell had considered Leestel and him a part of 'us.'

Gell saw that Djem had pointed his whole body towards him. "I always wanted to speak the word 'miscreant'; I have only seen it written."

Belgom almost stopped. This halted Leestel and Djem. Moel was right behind Belgom; they and Gell came up to the two humans. Belgom listened internally for a moment, that was obvious, and then said "I deputise you, Gell," he pointed, "you, Leestel Kemmel," he pointed again, "and you, Djem Galt Dorodden," he pointed for a third time, "to stop and bring into custody Kilbenvin." At that, Gell swam vigorously. Leestel and Djem came after him. With the stop they had fallen behind.

"Kilbenvin is heading for the entrances to the lower caves, those closest to the edge. They are longer than ours up here, and connect to a different set of houses. We will catch up before he hides . . . no, we won't, not if he crosses the airport volume. That is a shortcut. Since we started radioing people into computers in orbit rather than carrying them, the number of flights has dropped to one every six days. It is a safe volume." Gell suddenly looked worried. "Maybe we won't catch him."

"According to its schedule, a one-in-every-sixth-day ramjet is due to take off momentarily," said Djem. "Is that good news?" "That is bad news," said Gell. "We definitively should avoid that volume." He angled away. "Why?" asked Leestel. "We can avoid the take off path."

"It is not our bumping into the jet that is dangerous," said Gell. "As you say, we can avoid it. Rather, it is the noise and heat from the rockets that bring it up to ram speed, mostly the noise. Remember, this atmosphere conducts sound much better than your thin air."

"I see," said Djem, considering Earthly and Melian jets at the same time he swam quickly. "To reach the minimum speed of a ram, why don't you use quieter, restartable turbines, like we do?"

"Solid, expendable rockets are traditional," said Gell. "They are built by assemblers so they don't cost anything. As for the airplanes themselves: a single attempt at landing almost always succeeds; we have never had a crash that killed people on a tree. When a landing fails, the airplane sinks into the depths. It is vaporized. An assembler builds another ramjet. Failure is rare. In any case, by that time, the ramjet is not carrying any payload.

"A ramjet serves only to carry its payload into the near vacuum that is a little distance above us. That kind of airplane always stays close enough to its take off that its pilot is remote. Such a jet cannot go into orbit itself; it masses too much. We have never lost a payload being accelerated by a set of cables. We have lost one or other of the microwave transmitters that provide energy to the pallet carrying the payload, but there are so many of them, the loss of a few is irrelevant."

"I knew that," said Leestel. "But I'd forgot," said Djem. "Thank you."

Gell looked at Djem. He did not know whether Djem was being diplomatic or meaningful.

Kilbenvin knew that hardly anyone flew the ram anymore and assumed it was not going to fly while he was in the volume. He was wrong. As he swam through the airport volume, the ramjet started. Even though they were far away, Djem, Leestel, and Gell heard its rockets. It started exactly at its scheduled time. Djem decided that close would be dangerous. He could not see Kilbenvin.

Djem would not want to live immediately outside the airport boundary either. Then he looked down and saw only farm land. No doors, no windows.

Gell could not see where Djem was directing his attention, but guessed. "We zone strictly for farm fields without animals," he said. "Since the land is close to the city, farmers make a little more. Workers who must hear the noise get paid more. There are not that many agricultural workers left, so they can negotiate comfortably. We don't protect them. The police help others."

"The police help negotiate?" asked Djem.

"Only the weaker," said Gell. "The police are the protectors. It's their job."

Before Djem could say anything more, Gell continued. "Yes, I know we could replicate food from inorganic assemblers, but that is not done. People eat what is grown, what is replicated by an organic assembler. We are not like Melior, where certain items are grown from organic sources and certain items replicated in a different way. Everything tree tortoises eat is grown organically."

Before any of the three had time to swim around, they heard a radioed message. "In the airport volume, radar has picked up a non-moving object the right size and reflectivity to be a dead tree tortoise. The ramjet is well away and the airport will be quiet. You may now enter the airport volume and check it out."

"I bet that is Kilbenvin," said Leestel. "He knew a considerable amount, but he did not know how to get away with murder. He should never have run; when he did run, he should not have crossed the airport when the ram took off."

"He was desperate," said Gell. "He wanted to live," said Leestel. "We still don't know whether it was him," said Gell. "No, but we can be pretty sure," said Leestel.

They swam into the airport volume, followed radioed directions towards the body, saw it, and finally identified it. According to documents on it, the body was Kilbenvin's. Belgom and Moel swam up a little later. Belgom took one look and said, "Yes, that is Kilbenvin."

He looked at the two humans. "We can record him. Can you interrogate his mind? I want to discover whether he had any colleagues, which I doubt, and his motivation."

"If you can record him soon, we may be able to help. We will try," said Leestel.

Then they returned to the protector's headquarters. At that point, Belgom said formally to all three, "You are released from our forces. Thank you." Then another tree tortoise paid them.

Leestel said to Djem, "I bet you never thought you would be deputized in an alien police force!"

"Never," said Djem, looking amazed. "But life has been strange. On Earth, I never thought Melior existed. On Melior, I never thought aliens existed." He stared at his pay, sinkable, heavy coins, although no one knew where he was directing his attention. "These coins can be duplicated," he said.

"Yes," said Gell, "but so far, nobody has, at least, not that I know of. They would be worth duplicating: their values are more than their weight in metal. However, so long as crooks don't get hold of or gain

access to assemblers, coins won't be duplicated. We don't have corrupt guards or politicians like you, or far fewer. Eventually, we will shift. Our people will become more corrupt. In the meantime, people like coins, even if they do weigh them down."

"They like solid symbols, just like humans." Djem moved his eye and ear stalks forwards and backwards. Gell saw that as a shrug.

By the time Kilbenvin's body had been recorded, the Melian software was on tree tortoise computers. It was a part of the huge amount of material that had already been given to the tree tortoises. There was no delay in obtaining it, speed-of-light or otherwise.

"We did not know you would want this," said Leestel, "so we did not point to it. It was impossible and is still very hard to decide what you will need and what you won't. We have pointed to and talk about what we think is important; but that is not necessarily what you want to learn." Her comments pre-empted Gell, who was starting to think that the humans had not pointed to many things. 'Maybe,' he thought, 'Leestel is right. Maybe she is lying. We cannot do much except study more and interact with humans more ... perhaps that is what they want.' He decided he should be more accurate, 'what this portion of them want.'

It was harder to adapt the interrogation software to a different species than to obtain it. Moel said, "Let's ask Tuppak what to do. I should be able to figure this out eventually; I understand how it works with humans; but he should be much quicker."

"With tree tortoises?" asked Belgom. "Yes," said Moel, "even with tree tortoises. He is a genius. And he knows as much as I do about tree tortoises, plus he knows Earth and Tegmar. I know them, too, but Tuppak has been thinking about them more."

"Tegmar?" asked Belgom again.

"Tegmar does not have a sentient species on it, not technologically capable," said Moel, "but it does have complex life. It is the next planet out from Melior. Its planetary life does not come from the same background as Earthly life either. It is not part of that humans call an 'Arrhenius spore trail.' Tuppak has been thinking a long time about the three evolutions. Of course, ours is the most different he has seen. On the other side, he probably knows the software. I am just learning it."

Not only did the message to Tuppak suffer a speed of light delay, but he had shut himself out of contact and was sleeping. Leestel overcame the hindrances. "I would not wake him," she said, "but by the time my message reaches Ulterius, he should be awake. He is carrying his radio; it is built into his head. He just put a 'do not interrupt' note on it. I can overrule that. This could become," she made a tree tortoise smile, using her middle and back fins to move her whole body backwards

and forwards, "an 'interspecies diplomatic incident' and I am the senior person in the Ulterian Interior and Foreign ministry." Then she looked rueful. "This will be the first time I have done anything since Melior!"

"Not quite," said Gell. "From my point of view," said Leestel. Gell quietly clapped his forefins together. He knew he could not argue 'her point of view.'

Kilbenvin's brain and other neurons were too damaged by noise for him to be reborn from that body. But the software was able to discover that he had no colleagues, a lack that Gell did not find surprising, and his motive, which Gell did. Kilbenvin had hoped to gain status soon, before the time of the first reversions.

"I think he was stupid," said Leestel. "As I said earlier, he should never have run; he should have declared his innocence and bluffed us. He was not smart like Belgom, who not only knows how to protect himself but listens to outsiders like me. How could Kilbenvin gain status?"

Then, before anyone had a chance to say anything, she turned to Belgom. "What are you going to do when Veltom is reborn? As far as I know, he was last backed up on your original planet. He will have lost all his personal memory of here."

"If we wait until a new body is grown, a new body that looks like him, he will lose yet more memory. I think we will have to wake him up soon into a standard body. We should probably put him into an inorganic mind, so it will be easy to shift from one body to the next."

Djem protested. "Will Veltom accept that?" he asked.

"He won't have any choice," Belgom said. "Fortunately, we don't worry when we are reborn into an inorganic substrate." His explanation was not quite relevant. "In the early days," he said, "tree tortoises explained what they otherwise could not understand with djinns and the like. We never developed the idea of a part of ourselves that could not shift bodies." The comments were true. Unfortunately, Belgom was wrong about most tree tortoises. Like humans, they resisted shifting into inorganic substrates. Fortunately, Belgom was right about Veltom.

Belgom stopped for a moment. "As for Leestel's question," he said, "until Veltom comes up to speed — that is a phrase you humans use, right? — until Veltom learns what is new, I will stay in position. Then I will become number two again. He is good."

"Will that distress you?" asked Leestel. Although Djem understood she was not being diplomatic, he was curious how Belgom would answer. Gell did not say anything.

"I do not have the same ambition as you or Kilbenvin," Belgom said. "In this organization, most of what we do is specified or traditional. We lack the discretion you humans have. A more senior position does not matter. Kilbenvin was very stupid."

"He may have picked up ideas from us humans," said Leestel. "You are going to have to watch for that. My sense is that ambition is determined by culture more than genes. Your culture is going to change."

When he was reborn, Veltom was irritated at his lost years. As he saw it, he had fallen asleep on his home planet and woke up on the Ulterian Jovian after it became established, rather than at its beginning. He had to learn from Belgom the changes he had devised while in another body. This body was standard. It was not like his own, although it was adequate.

Veltom had been murdered. He did not like that at all. He especially did not like Leestel's comment that Kilbenvin may have picked up his ideas from humans. He feared it would be true. Humans were going to change the culture. It was going to change more than it had changed since the development of industry, maybe even before that.

Veltom welcomed Belgom's placing him in an inorganic mind. He told Belgom that. It was easy to back up, which he did now once a day.

Chapter 25

Murm swam over the stones in the large entry to the Council. He did not know, but years before and light years away, humans had broadcast a picture of a diplomat coming into the same entry. The plain stones below showed a tree tortoise dramatically.

Murm did not think about his appearance; instead, he wondered whether his suggestion would succeed. Fortunately, he looked fine; in addition, other members of the council concerned themselves more with long term reality than with looks that could be manipulated in the short term. They know about both and did not want to be influenced by others' appearances.

Unlike most corridors, which stayed close to the surface, the entry went into the depths of the tree. Highly polished light tunnels poured brilliance. Some of them were long. Initially, they were very expensive. Their openings were not in the corridor's top center, but towards its top left. The tree did not spin around, at least it had not since the tunnels were dug. Because of the planet's strong magnetic field, Murm knew he swam south. Consequently, the entry tunnel always gave the impression, to most tree tortoises an unconscious impression, of a time in the mid-morning.

The tree was old and floated high; that brought bright sunlight. It did not have to penetrate so much air. At the same time, the tree was cooler than any lower. That justified more clothes, more expense, and more luxury. Cooler air called for different walls, too, different types of rock, different types of paint and plaster, different tapestries; individuals in the central tree had many choices.

Displays were to the right. Murm paid no attention to the full-size replica, half exposed, of one of Alguldintirn's human powered galleys. Murm had studied that replica years ago. It showed the bottom half of the galley, with statues of a dozen rowers on each side, each pushing a feathered oar sideways.

Another display showed metal nodules and early machines for making metal wire, insulation, and electrical devices. Like Tirn's galley, its location was on the right, illuminated from the top left.

As Gell had explained one night on a quite different planet, trees sorted and sequestered fine dust from the atmosphere. Too much dust would poison everything alive. They concentrated the dust into nodules that were safe.

Early tree tortoises who had a more sensitive north sensing ability than other tree tortoises learned to detect what they called the 'aura' produced by a few metals. They sensed the metals' magnetic field, but none of the tree tortoises knew that.

When tree tortoise farmers discovered that iron plows dug rougher soils and, even more important, when warriors and those who funded them discovered that iron swords and armour held out better than any equivalent, the sensitives became valuable. Almost simultaneously, several trees discovered how to take reports from the sensitives and map them. The maps showed metallic lodes which miners could dig. The sensitives ended as slaves and the trees formed small empires.

Only Tirn's tree formed a large, world-wide empire and that was long after warriors shifted to iron.

Every tree contained nodules, but in narrow wind zones, trees at the same level collided more often. There was not the width to protect them. In a collision, trees' edges broke apart. The lighter organics floated up and formed organic layers on the bottoms of trees floating above. The denser metals and sands sank and formed inorganic sedimentary layers on heavier trees floating below. The denser roots also sank but more slowly. They formed organic sedimentary layers.

Such spills prevented sentient or nearly sentient life in those zones. The spills were too frequent. Tree tortoises and others almost as advanced could see a collision coming; they could get away. But their predecessors could not understand and did not escape. So there were none. Primitive tree tortoises crossed narrow wind zones by eating the life that survived spills. They settled and evolved on trees in wider wind zones.

Generations later, traders found deep caves that were always safe. Inns in them enabled traders to eat and sleep comfortably. Although the central government gained nothing, it knew that traders, police, other agents of the central government, including those who protected tax revenues, preferred inns, so it let them be.

Not until curiosity, science, and its funding became important could a strange fellow made use of the newly invented 'torque compass' to map the magnetic fields on several uninhabited trees. Other tree tortoises shunned Helderbin because of his obnoxious character. He worked alone.

Fortunately for him, the first tree on the narrow wind zones that he mapped did not carry much metal — but carried more than expected. Most did not believe how much Helderbin found anyhow. But a funder in the central tree decided to shift the position of a to-be-dug geological well from one place to another. The tree tortoise wanted to determine what caused Helderbin's anomaly. He knew the scientist, as strange as he was, could not conceive of fraud and was careful with his instruments. Helderbin did not make stupid mistakes; he only made complex ones.

Just that one well paid for the project a double-dozen times over. The scientist's name, Helderbin — behind his back he was often called 'Helderdelbybin' — was shortened to a single syllable, 'Bin.' Bin was

smart enough to spend a very short time on the central tree and return to isolation as soon as he could.

Over time, the price of metals fell. Miners learned to dig from safe, existing caverns into huge magnetic lodes. They found non-magnetic metals along the way, as well as sand and other dross.

With widespread, cheap metal, inventors and innovators created a revolution in technology. The tree tortoise world changed.

Murm swam on. He came to a room, not the reception room for representatives of different factions, for tree tortoise diplomats, but the Council Room.

It was deep in the central tree. Like the entry, long tunnels carried sun light to it. As always, Murm was amazed at how bright it was.

The members of the Council, officially advisers and electors, settled in a ring. None had tables or writing surfaces in front of them, but each had a horizontal bar behind his or her position. Like the others, Murm gripped his bar with a rear flipper.

Shortly, everyone came to their place. After the ceremonial beginning, which did not last long, Murm spoke.

Glarn responded. "Your proposal means that tree tortoises skilled at getting elected will predominate," he said.

"Yes," said Murm. "We are chosen because we are successful in a bureaucracy. I don't think the proposal will produce better people. On the contrary. All I can say is that a similar set up does enable the humans to make changes more quickly than we. They don't always change quickly or appropriately, but they do change for the better more often than we. Whether we want it or not, our interstellar expansion forces change upon us."

"Fewer people from the central tree will find work," said Glarn.

"That is also true," said Murm. "I am not saying this will be a happy change; only that it is less bad than alternatives."

The rest of the Council looked on Glarn and Murm intently, although none could see that. The members all came from the central tree. None worried about themselves or about their generation; they presumed that anything like this had to take time. But they did see that at some point, their tree might cease being central.

"Murm is arguing that we no longer have generations to decide upon and to make changes." As was his habit, Dorb said what everyone knew. His words permitted everyone to think. "Even though interstellar distances are vast, and even though radio messages take years to traverse them, we will have to make significant changes more quickly than before. . . . It won't be simply whether to ask assemblers in space to make more sensors so we can detect an incoming space ship that is quiet. It will be as intrusive as whether to include reversion with rebirth."

"We already include reversion with rebirth," said Glarn, "and we made the decision and implemented it fairly quickly."

"Yes," said Dorb. "And we will have to make additional decisions that will be equally or more intrusive. Hardly anyone knows about rebirth yet. Murm's point is that because of interstellar expansion, our society will have make changes to the way all tree tortoises live. And we will have to make the decisions and implement them in less than a generation.

"Presuming we stay as we are, we or our successors will make some appropriate decisions. The reversion with rebirth is an example: that was a fairly easy decision" — it had not been, but Dorb did not say that — "and not very intrusive. Other issues, I don't know what to expect, will be harder and more intrusive."

"You don't know what other issues to expect . . ." said Glarn.

"That's right," said Dorb. "All I know, all anyone can know, is that there will be other, intrusive issues that will need to be made quickly and need to be implemented rapidly.

"The goal is to gain support for the central government from and by enough adults even though changes come fast. That means we must involve people from other trees. We cannot simply rule them. They must overtly and legitimately help in running society. For the first few generations, everyone will follow our lead. After all, we are more experienced!"

Murm noted that Dorb did not say they were 'better' only that they were 'more experienced.'

"I don't know what will happen after a few generations," said Dorb, "but that is the point, nobody knows."

"Are you suggesting a governmental structure like the one we devised for our colony?" asked Glarn.

"Not exactly," said Murm; he knew the topic better than Dorb. "However, it will be similar. As far as I can determine, that is the only form that brings more or less uncaring adults into acceptance."

"Most adults are stupid," said Glarn.

"No doubt," said Murm, "but they can cause damage; if they revolt, they can kill people. We can put down revolts. The purpose of this suggestion is to avoid revolts in the first place."

"Killing is less important when we have rebirth," said Glarn.

"I agree," said Murm. "But how many tree tortoises want to wait one of our years for new bodies that look like them? How many of our supporters want to enter a body with memories from when the data packets supplying them were last updated? Those memories may well end years before. Even when memories are put immediately into a standard body or a robot body, those memories could well be old."

"They don't have to be long, empty spots in their memories," said Glarn.

"No," said Murm, "but how many tree tortoises will go into an inorganic substrate and make backups every day?"

That rhetorical question stopped Glarn for a moment. As far as he knew, only tree tortoises whose minds entered into an inorganic substrate could back up quickly and easily. He liked the idea of reentering a double-dozen year old body, but he was not going to have his mind enter an inorganic substrate. He was not sure why, but he was not sure it was safe.

Glarn cursed himself; his argument for safety rather than going into an inorganic substrate was similar to Murm's argument. Both argued against risking unknown dangers. To save them all, Murm wanted to change the form of government; to save himself, Glarn wanted to enter an organic substrate.

Murm kept to the same response pattern, agreeing and then introducing a complication. He kept to his argument, too, that the high cost of low likelihood events more than exceeded the low cost of the known.

Glarn changed topics. "Will revolts happen?" he asked.

"They may not," said Murm. "This is a question of what might happen and our hurt if it did."

"You are proposing a major change, 'intrusive' as Dorb said, to handle a possibility," said Glarn.

"That's right," said Murm. "An alternative that happens may be dangerous. It does not matter whether it is internal, such as a revolt, or external. I fear such an alternative so much that I am recommending we make the first fundamental change since the time of Tirn.

"I cannot promise you that disaster will happen; it may not. I cannot promise you that as presently constituted we will fail to make rapid decisions; we may decide. I cannot promise you that a new structure will decide appropriately; it may decide poorly." Murm smiled. "Certainly, no one should have large hopes for a new structure moored to tree tortoises who are skilled at being chosen by stupid people. That kind of organization will sometimes decide inappropriately or not decide at all.

"All I can say is that I fear we will do worse by going as we have. We are living in new times."

"You spoke of a governmental structure," said Glarn, " 'that brings more or less uncaring adults into acceptance.' What do the uncaring do?"

"You already know the answer to that question," said Murm. "Once in a while, they evaluate the people who actually run the government. They temporarily stop being uncaring. Depending on their evaluation,

they throw out the people who run the government or they keep them. Their ability to change the people in the government is like our ability to change an executive. We often pick well, but not always."

"A politician will believe he is doing right and a smart one will shape others' observation so they see the same."

"Yes," said Murm, "so we need equally smart investigators who not only seek to look into it all, but are able to. The humans speak of 'accountability and transparency.' We must investigate. As I said, this is a big change."

Quite without realizing it, Glarn clapped his forefins together in slow and quiet strokes. He agreed, the proposal would produce big changes. "What about privacy?" he asked. "Humans have abused the new technologies. Tree tortoises could learn to do the same."

"Privacy is not the opposite of transparency, not in government or in any other organization. Seldom are the goals to hinder particular individuals."

"Police have that goal."

"Police go after crooks," said Murm. "We already have restrictions on what police can do with the information of people who are not crooks. Tirn organized an army that went after trees; it faded away after all the trees were conquered. We are not in the past; and most people are not crooks. They hardly ever meet police.

"I know, some human countries have made it impossible for their people to avoid police. I think that is criminal. We tree tortoises have not done that. I don't think we will."

"Not everyone will go along with rapid changes during their lifetimes. If your proposed changes are implemented, more people will meet police; and they will be unhappy," said Glarn.

"That's true," said Murm. "That's another disadvantage. The only advantage of my proposal is that it beats the hurt to all of us from staying as we are.

"As for privacy and transparency: nobody worries about agglomerated data, except for those who are afraid it will show they did badly in striving for their proper goals. It is and will continue to be dangerous to provide private data to individuals in government. Besides minimizing the collection of that kind of data, we will need even more anti-corruption groups. Fortunately, as the saying goes, *corruption is the result both of monopoly and of discretion without accountability.*" As he said the rule, Murm spoke differently. "If we increase accountability and decrease discretion we will have less corruption."

"Should a choice be for one year, two years, or three years?" Glarn knew that his Jovian year was a little more than six times as long as

a terrestrial year. “Or should that choice be for so long as supporters have confidence in themselves?”

Murm tossed the question back. “Which do you think would be better for us tree tortoises?” he asked. “We on this Council pick the current executive for two of our years. The proverb says, ‘the first half-year is for learning, the second is for doing, the third is for fixing the mistakes of the second, and the last is for grieving, since not all mistakes can be fixed . . . ’

“I think that whatever we do, we need to give time to people in the government. Otherwise, either they will be moored to others or they will find less overt ways to learn. That is a significant detail, but you as a group may decide differently than I as an individual.”

“Let me think about this,” said Glarn. He did not say what he meant by ‘this’. Nonetheless, Murm counted a victory. Others clapped their forefins together. So did he. Thinking about the proposal was all he sought at this stage.

Chapter 26

Almost every human backed up once a year on the day after their birthday. After many years, researchers on Melior had discovered how to revive a copy of a body frozen for recording. So computers could now make a duplicate. (The original was destroyed during the recording.) An assembler produced an exact copy of the old body, including its age. That contrasted with a force-grown body. Although the brain of the exact copy needed to be revived, it was not impressed on a force-grown body. Such a brain snapped alert without taking time or requiring help.

A reviving computer took time raising the temperature and ensuring that the previously cold body and brain became a warm and living person again. People slept through the whole process.

When the signals had to go sideways to another relay because the two planets were on opposite sides of their sun, the time taken for revival was about equal to the speed-of-light delay from transmitting the data back and forth from Ulterius to Nebber by radio. The whole back up took a half day or so.

Instead of just turning around immediately, the humans took to visiting the Jovian planet for a terrestrial day. The humans liked the convenience; and in any case, computers on Ulterius easily kept the revived body and brain asleep.

When the data returned to Ulterius, the memory was merged seamlessly with the human existing memory. Such merges avoided duplicates, except for those temporary duplicates which were inherent in the process.

The humans knew of Eltis' agreement with Gell, that they be hostages to the tree tortoises. However, none thought that either government would hurt visitors of the other, and they did not expect other groups to cause trouble, so the humans went every year. Indeed, the humans were correct. The trip was not dangerous.

After the home government sent colonists as dead data packets, many more tree tortoises lived on the system's Jovian than humans who lived on Ulterius. The tree tortoise population eventually exceeded that of Melior.

However, even after they learned about reviving the frozen living, and found that humans had given them that information in the beginning, but not pointed them to it, tree tortoises did not back themselves up as frequently as humans. Moreover, they never developed the habit of visiting Ulterius when they backed up. That was just as well. Even if they had backed up only once a Jovian year, many more tree tortoise tourists would have come to Ulterius than human tourists go to the Jovian.

Instead, the hostage exchange depended on tree tortoises who decided to visit the human planet, to walk on a solid in an atmosphere that did not buoy them up. Every terrestrial year, about one in half a gross did. Even though the tree tortoise Jovian planet carried vastly more people, over twice as many humans visited the tree tortoises than the reverse. Nonetheless, that worked out.

Tree tortoises had more difficulty adapting to the human world than humans did adapting to the tree tortoise world. The humans swam under water. They knew about creatures who lived in a fluid nearly six gross as dense as their air: fish, sea mammals, corals. Moreover, all the humans knew about virtual presence. When they were in the Melian system, many had worn a virtual presence on the surface of Tegmar.

Appendix A Counting in Base Twelve and in Base Double-Twelve

The base twelve counting system on Melior became possible for older people only because they were all born again. Consequently, they all carried internal computers and understood information that had been inserted into their data packets while they were dead. Otherwise, they would have had difficulty converting from base ten to base twelve.

Young people grew up with base twelve. They had no more trouble than anyone learning base ten, perhaps less.

Indeed, because their educational system encouraged them to count on the tips of their fingers and those knuckles closest to those tips, they thought of base twelve as natural. When they bent their fingers to look at them, they divided the indicators into two groups of 6, or three groups of 4, or four groups of 3. Specifically, school and adults encouraged children to look at their left hand, palm facing them, with their fingers bent. That way they could easily see the four tips of their fingers and eight knuckles, twelve in all. They were also taught that the tip and two knuckles on the thumb marked a dozen, two dozen, and three dozen.

It goes without saying that some children were confused that in base twelve a third is 0.4, zero dot four-small, and a quarter is 0.3, zero dot three-small. A rite of childhood involved understanding and remembering the symbols and their meanings.

The language included spoken words:

```
gigantic-gross  1,000,000,000 base twelve,   5,159,780,352 base ten
huge-gross      for 1,000,000 base twelve,       2,985,984 base ten
great-gross         for 1,000 base twelve,           1,728 base ten
gross                 for 100 base twelve,             144 base ten
dozen                  for 10 base twelve,              12 base ten

small   or hour      for 1/10 base twelve,            1/12 base ten
little  or prime    for 1/100 base twelve,           1/144 base ten
minute            for 1/1,000 base twelve,         1/1,728 base ten
second           for 1/10,000 base twelve,        1/20,736 base ten
tertiant        for 1/100,000 base twelve,       1/248,832 base ten
tiny          for 1/1,000,000 base twelve,     1/2,985,984 base ten
speck     for 1/1,000,000,000 base twelve, 1/5,159,780,352 base ten
```

When speaking of time, Melians often replaced '`small`' with the word '`hour`', which lasted two terrestrial hours, and replaced '`little`' with the word '`prime`', which lasted ten terrestrial minutes.

On Earth, a base twelve minute was 5/6 of a base ten minute, a base twelve second was 4.17 base ten seconds, and a tertiant was a little more than a third of a base ten second.

In speaking numbers in English, the words were shortened to:

`giga` (with hard 'g's)`, huge, great, gross, and doz`

Thus 1,234,567,890 in base twelve, which is 6,140,565,036 in base ten, was pronounced:

```
one-giga two-three-four-huge five-six-seven-great
    eight-gross nine-doz zero
```

A shorter number was pronounced using the same mechanism. Thus, for 17,550 in base twelve or 33,612 in base ten, people said:

```
one-seven-great five-gross five-doz zero
```

The smallest three products of twelve only differed each by one place:

```
great for 1,000 in base twelve
gross for 100 in base twelve
doz   for 10 in base twelve
```

as did the first six fractions:

```
small for 1/10 in base twelve
lit   for 1/100 in base twelve
min   for 1/1,000 in base twelve
sec   for 1/10,000 in base twelve
tert  for 1/100,000 in base twelve
tiny  for 1/1,000,000 in base twelve
```

Consequently, 7,890 in base twelve was pronounced seven-great eight-gross nine-doz zero and 0.345 base twelve was pronounced zero dot three-small four-lit five-min.

A nanometer in base ten is more than five speck meters. An atom's width, approximately one-tenth of a nanometer in base ten, is little more than half a dozen small speck meters.

Addition

In base twelve, seven-great eight-gross nine-doz zero plus six-gross eleven-doz eight summed to eight-great three-gross eight-doz eight.

In Emacs Lisp and base ten addition:

```
    ;;        great     gross     dozen    base twelve    base ten
    (+ (+ (* 7 1728) (* 8 144) (*  9 12) 0) ;; 12#7890 == 10#13356
                 (+ (* 6 144) (* 11 12) 8) ;; 12# 6B8 == 10# 1004
    )                                      ;;              +
                                           ;;               -----
;; is
    (+ (* 8 144 12) (* 3 144) (* 8 12) 8)   ;; 12#8388 == 10#14360
```

Base Double-Twelve

The alien tree tortoises' number system is based on their fins and the lobes on them. The tree tortoises swim in the dense atmosphere of a Jovian. Each has a total of six fins, two in front, two in the middle, and two in the back. Each fin is divided into four lobes.

Twirls or circles are used for numbers that correspond to the front or back fins. Middle fins are shown by a short vertical line. A circle or line indicates the tree tortoise body. Its direction from the center of the symbol tells us which side the fin is on. A fin on the right has its body on its left.

Tree tortoises count from the front right. A twirl or circle above the line indicates the front, a vertical line indicates the middle, and a twirl or circle below the line indicates the back.

The symbol for zero consists of a circle with no numbers, or, put another way, a body with no lobes marked. Since the circle indicating the body is below the line, the body must be viewed from the back.

In base ten, 24 is the number for the base of a base double-twelve number system. Double-twelve is twenty-four in base ten. In base double-twelve, the 24 of base ten consists of two symbols, 10, the way 10 in base ten is the number which is equal to the base of a base ten number system.

In base twenty-four among the tree tortoises, the base double-dozen number 10 is:

```
   ___
    0          => 0       ;; smaller value on top
   0__|_       => 1       ;; larger value on bottom
```

Among tree tortoises, an old and uncommon symbol is `_|__0`. That is for the number 24 in base ten and has a single upright. It is similar to `0__|_`, the symbol for one, but on the other side, as it were. The one has a single upright, too, but to the right of the twirl. The symbols are mirrored.

The right lobes stand for the first half of the double dozen numbers that make up the base and the left lobes stand for the second half.

The numbers look like this:

```
one-doz twelve,
24, twenty-four   _|__O          1, one     O__|_

one-doz eleven,
23, twenty-three  _|_|__O        2, two     O__|_|_

one-doz ten,
22, twenty-two    _|_|_|__O      3, three   O__|_|_|_

one-doz nine
21, twenty-one    _|_|_|_|__O    4, four    O__|_|_|_|_

one-doz eight
20, twenty        _____          5, five     _____
                   |  '                     '  |
one-doz seven
19, nineteen      _______        6, six      _______
                   | |  '                   '  | |
one-doz six
18, eighteen      _________      7, seven    _________
                   | | |  '                 '  | | |
one-doz five
17, seventeen     ___________    8, eight    ___________
                   | | | |  '               '  | | | |
one-doz four
16, sixteen       _____          9, nine     _____
                   |  O                     O  |
one-doz three
15, fifteen       _______        10, ten     _______
                   | |  O                   O  | |

one-doz two
14, fourteen      _________      11, eleven  _________
                   | | |  O                 O  | | |

one-doz one                      one dozen
13, thirteen      __________     12, twelve  ___________
                  | | | |  O                O  | | | |

                      0, zero    ___
                                 O
```

In base ten, 26, twenty-six, is the number 12 in base double-dozen (i. e., in base double-twelve or in base twenty-four). Tree tortoises write it like this:

```
O__|_|_        => 2       ;; smaller value on top
O__|_          => 1       ;; larger value on bottom
```

In base double-twelve, 100 is twenty-four squared, or 576 in base ten.

In base double-twelve, 379.3, which in base ten is 1905.25 is written by tree tortoises as:

```
O__|_|_|_      => 3   ;; smaller value on top

  |            => .

_____          => 9
O  |
_________      => 7
'  | | |
O__|_|_|_      => 3   ;; larger value on bottom
```

Examples of Addition

In base ten, $5377 + 4180 = 9557$

In base double-twelve (i. e., in base twenty-four), that is
$981 + 764 = 16, 14, 5$

The first number:

```
;; (in Emacs Lisp; colons before unevaluated expressions)
(+    1
   (* 8 24)
   (* 9 24 24)) ;; --> 5377
```

or according to the tree tortoises:

```
O__|_
___________
'  | | | |

_____
O  |
```

The next number is 4180 in base ten:
(in base double-twelve it is 764):

```
(+    4
   (* 6 24)
   (* 7 24 24)) ;; --> 4180
```

or according to the tree tortoises:

```
 O__|_|_|_|_
 _______
 '  | |

 _________
 '  | | |
```

The sum of the two numbers is:

```
(+    1
   (* 8 24)
   (* 9 24 24)
      4
   (* 6 24)
   (* 7 24 24)) ;; --> 9557
                       ;; which is 16, 14, 5 in base double-twelve
                       ;; (i. e., in base twenty-four)
```

According to the tree tortoises, the base ten number 9557 is number 16, 14, 5 in base double-twelve or *ge*5 in another conventional human notation. In tree tortoises symbols, it is:

```
_____
’  |        =>  5     ;; smaller value on top
_________             ;; (colons before comments)
 | | |  0   => 14
_____
 |  0       => 16     ;; larger value on bottom
```

Tree tortoises who use the most conventional algorithm add from the top down rather than from right to left as do humans who use the same algorithm.

In other words, when two or more smaller values sum to an amount larger than the next higher base, that value is incremented and the smaller value is noted in the smaller place.

A final example is to add the base ten values of 4184 and 13770 to yield 17954.

In base double-twelve or base double-dozen, which in base ten is called base twenty-four, the augend and the addend are:

```
 10#4184 = 24#nli = 23,21,18

10#13770 = 24#768 =  7,6,8
```

and their sum is:

```
10#17954 = 24#1742 = 1,7,4,2
```

The first stage produces intermediate results. Thus:

```
     _________           ___________          0__|_|_  ;; smallest
(18)  | | |  ’    + (8)  ’  | | | |   = 26 =  0__|_


(21) _|_|_|_|__0   + (6) _______       = 27 =  0__|_|_|_
                          ’  | |                0__|_

                          _________            _______
23 _|_|__0        +  7    ’  | | |     = 30 =  ’  | |
                                                0__|_    ;; largest
```

Note that in base ten:

```
26 + (* 27 24) + (* 30 24 24) = 17954
```

The sum converted from base ten to base double-dozen:

```
10#17954 = 24#1742
```

and, in base double-dozen, the addition is:

```
24#nli + 24#768 = 24#1742
```

The second stage gives us our final results.

In the first place of the total, the original in base ten was

```
(24 + 2) = 26
```

After removing twenty-four in base ten, two is left over.

In tree tortoise notation, two is

```
O__|_|_
```

Bear in mind, the ones' place original total in base ten was twenty-six.

In base twenty-four (i. e., in base double-twelve or in base double-dozen), the original addition of the ones' place summed to 12 with the number 1 in the double-dozen place.

In the double-dozen squared place, we find that a six was already in the one's place (in base ten, the one's place is 'times 24'). We need to carry one more from the double-dozen place to it.

In the double-dozen to the third power place, we need not carry any numbers. In base ten, the value of the number in the next lower place was below twenty-four.

Put another way, in Emacs Lisp:

```
;; base ten                                        base double-dozen
;; Earthly human notation                          tree tortoise notat

(+    2            ;; ones' place, smallest value       O__|_|_

   (* 4 24)        ;; double-dozen place                O__|_|_|_|_

   (* 7 24 24)     ;; double-dozen squared place        _________
                   ;;                                   '  | | |

   (* 1 24 24 24)) ;; double-dozen to third power place O__|_

;; 10#17954 = 24#1742
```

Among tree tortoises, an old and uncommon symbol is `_|__O`. That is for the number 24 in base ten and has a single upright. It is similar to `O__|_`, the symbol for one, but on the other side, as it were. The one has a single upright, too, but to the right of the twirl. The symbols are mirrored.

The right lobes stand for the first half of the double dozen numbers that make up the base and the left lobes stand for the second half.

Appendix B Sureness or Certainty

People have always judged evidence. They have had to. Otherwise, they suffered or died. Before becoming important on Melior, even the formal concept of sureness or certainty was centuries old.

The Melians adopted rules that David McAllister on Earth had specified centuries before. In school, the purpose was not so much to cause humans to use numbers and mathematics, as to inspire them to investigate their use of evidence: how sure were they of it; what was its accuracy — one part in a dozen, one part in a gross, one part in a great? How to combine various judgements? In the end, after forgetting the mathematics, the notion became a part of how Melians considered the world. However, the robots — all the computers — could calculate readily, so they kept the mathematics.

A sureness or certainty is how accurate, truthful, or reliable you judge evidence to be. You can add new evidence to existing evidence. When the evidence is positive, this increases your certainty, as you expect. But you never become completely sure or certain.

To make the mathematics possible and to help the robots, a phrase such as 'suggestive evidence' is given a number such as 0.6 in base ten and 'strongly suggestive evidence' is given a number such as 0.8.

Each bit of evidence is judged whether it is 'weakly suggestive' or 'strongly suggestive' or whatever. The rule for adding two positive bits is to reduce the influence of the second by whatever uncertainty remains of the first, and add the result to the certainty of the first.

Thus, if one bit of evidence is 'weakly suggestive' and given a numeric value of 0.4, and the other is 'suggestive' with a numeric value of 0.6, then the combination of the two,

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CFcombine-add (CFa CFb) = CFa + CFb(1 - Cfa)
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is

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CFcombine-add (CFa CFb) = 0.4 + 0.6(1 - 0.4) = 0.4 + 0.36 = 0.76
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In other words, 'weakly suggestive evidence' adds strength to 'suggestive evidence'. The result almost becomes, roughly speaking, 'strongly suggestive'.

A common sequence for suggested numeric values looks like this in base ten:

strongly or highly suggestive	0.8
suggestive	0.6
weakly suggestive	0.4
slight hint	0.2

In addition to adding two items of supportive evidence, there are rules for adding two elements of evidence against and for adding some favoring and some opposing evidence.

The three rules are:

- To add two positive certainties, as we have done before, add the first to the second, the second having been reduced by an amount that depends on the size of the first:

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  CFcombine-add (CFa CFb) = CFa + CFb(1 - Cfa)
  ```

- To add two negative certainties, combine the two factors as if they were positive and negate the result:

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  CFcombine-add-both-neg (CFc CFd) = -(CFcombine (-CFc -CFd))
  ```

- To add positive and negative certainties, sum the two and divide the result by the number that results from subtracting whichever is the minimum of the absolute values of the factors from one:

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  CFcombine-add-pos-neg (CFe CFf) =
      (CFe + CFf) / (1 - min{|CFe|,|CFn|})
  ```

(By the way, the order in which you combine certainties or uncertainties is irrelevant.)

Besides talking about combinations of evidence, schools also taught other ideas formally. For example, they explained why two pieces of evidence needed to be independent of each other. And they taught probabilities.

The goal was not to cause Melian humans to make calculations, but to lead their children to think of the 'determinative' branch of oratory as a way to persuade others that one judgement is more suggestive.

Then after judging which hypothesis is more likely to be real or true, children learned to debate what to do — Aristotle's 'deliberative' branch of oratory — using the general and vague notions that every political proposal had to:

Protect, *Preserve*, *Prepare*, and *Provide*.