On Land

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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 J, as in the French pronunciation of ‘Jean.’ In English, the name ‘Djak’ is spelled ‘Jack.’

AE is a long ‘A,’ as in ‘name.’ In English, the name ‘Djaems’ is spelled ‘James.’ In ‘James,’ a vowel is made long by following it by a consonant and a silent ‘e.’

Prologue

Djinbit remembered that as a child he had an insight that favored proof, as he saw it, rather than the lack of it. Like humans, he paid attention to his parents and people like them since they had his interests in mind, but he had waved a stick when he was on his own. He remembered waving a 'magical' stick and then finding that it was not magical. The first cloud he pointed it at vanished, which was definitely magical but not the second or the third. The clouds disintegrated normally. There was no proof that the stick was magical and his pointing it convinced him that it was not. After several experiences with notions that lacked proof and which failed him, he had his insight.

He went to University — his parents were rich enough to afford it and he never expected anything else. Moreover, it was away from home, in another city, and he looked forward to it. Besides stupid children of the rich and required classes which he found boring, he found he could take interesting classes and, most importantly, found other students with whom he could talk and argue. The other students insisted that he provide good evidence for everything, so he did.

He did not become a mathematician, although mathematics once beyond the beginnings had the most applications, the most patterns, and the most proof; he was not that kind of genius. He became an astronomer instead.

His courses became more specialized and, he thought, more interesting. He realized that not everyone would want to become an astronomer. Indeed, most would still be superstitious and not seek proof. Moreover, he dreamed of aliens, that is creatures of another planet, not foreigners, and he discussed them with his friends. In addition, there were popular books written of them. He disregarded the stupid ones, which he figured were frauds, and read the better, what he thought were better. As many did, he figured that mathematics was universal and could be used as a beginning although it would be necessary to show the alien a dictionary soon and figure out a way to express abstractions like 'love' and negatives. What if the alien had a bad memory? He discussed the problem with his peers. They said that there would be more than one alien and either they would have good memories or they would have a linguist. "We would be aliens to them; they cannot assume we would speak their language any more than foreigners do, the aliens on this planet. They have to understand differences."

"That almost make sense," he said. "What if they are very different from us and have a universal language? What if the aliens are alien?"

"If the aliens expect us to speak their language, and we don't, then the First Contact fails. It is not as if we have a chain of languages that could go between us. But it is much more likely that the aliens will not expect us to speak their language and we can expect them to learn ours since we will outnumber them."

Most of Djinbit's contemporaries believed in magic because they were told it, but Djinbit's parents had not told him, not that he remembered. (He simply forgot of the time when he was very young.) Perhaps when his parents talked to him, they thought he was too old for magic; he learned to speak late although he was still very young. By the time they could talk to him, he was no longer an infant but a child, a young child. Moreover, he sought proof for his own beliefs before his age-mates. His habit was confirmed in his university. His teachers had less influence than they thought. It was his belief that there were people not of his planet.

Chapter 1

Djinbit looked at the gaseous planet, Fulg. To a human he looked like a very large and unsegmented centipede. He was the length that a human was tall. The planet was in opposition and close, relatively speaking. 'At least,' Djinbit thought, 'it will be close if the mathematicians are right, not the old ones who spoke only of terms of circles and lines, but the new ones who think in terms of ellipses.' (It did not occur to him that in a cosmology based on 'circles and lines', the planet would be relatively close, too.) He looked through his new, reflecting telescope. Even the eyepiece was all mirrors. As a consequence, the planet did not show any colored rings as produced by the lenses he had used before; nor did it come with an enormous lack of contrast.

The main mirror was big enough and made with glass so it could be ground quickly. It was coated with a very thin layer of silver that Djinbit had splashed onto the mirror — the glass had not broken and the silver froze instantly. He did not think of depositing the silver chemically. In theory, he could also vaporize the silver in a vacuum and deposit it that way, but no one had yet come up with the idea of vaporizing a solid and recondensing it elsewhere. He polished the silver. He was able bring a light behind a pin hole to focus on a single spot both without and with the silver, although the image was very faint without the silver. Djinbit was fairly sure he could separate removed silver from the grit and the polish, and remelt it.

All but the minor mirror were part of a sphere, so he could tip the main mirror a little and reflect it off the flat, minor mirror.

The eyepiece was not so big. It was actually made of two mirrors so he could look more or less in the direction the telescope looked. He tipped them, too. Their grinding had gone faster and he did not use as much silver for the two as for the single main mirror. As for the flat, minor mirror, before letting the glass freeze, he had floated it on tin to produce a good surface. After the glass cooled, he polished it. Then he splashed silver onto the piece — he broke only one — and polished the silver, too. He would have to grind another eyepiece, but this was a beginning. Even though he had four reflections, the main mirror was big enough to see the planet comfortably. Stars did not have rings either. He would impress Sligtor, another astronomer and, in university, his main teacher.

Djinbit pulled back from the eyepiece. He was planning to draw what he could see of the planet and had to get his pad. He looked at the planet with his naked eyes and low down, he saw a star suddenly appear. He presumed it was a meteor and watched it slowly move to his left. He stuck his head out the open window. He had a very good sense of the constellations and where stars were, so he could track it readily. It became one of the slowest meteors he had ever seen. It faded while still moving. Maybe part of it survived to the earth and he would be able to get it. He had only two other meteorites.

He exhaled slowly. 'This was luck,' Djinbit thought. On the one side, he could not use his reflecting telescope for the rest of the night. He would ride, instead. He would ride in the direction he figured the meteor had fallen and then search for it. He did not know its distance, only its direction. Like the city, the direction was north. Most likely, it fell beyond the city and a farmer would find it in an otherwise clear field. It was Spring and the farmers had not yet planted. Djinbit grimaced; he would have to stay awake during the day tomorrow when the farmers were awake.

He went down stairs to catch a riding beast.

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Djil was pleased with herself. She had been piloting a spaceship. It had become an aerobody when it glowed. Then, when the vehicle was still traveling supersonic, but not glowing, she reconfigured it to produce wings. She produced a different set of them as she slowed below supersonic speed. She was an intelligent computer in a vehicle with a fair amount of range. She only wished they could have come in the day side but that would have given her less cross-range. With optical amping, she had seen a tower with a long telescope slung beside it. Fortunately, the vision of the tower had reached through her filters and she herself had recognized the long telescope, a very old design. She aimed towards it. She would just barely have the energy to reach it.

Then, the glider would stop, or almost stop. She could produce motors and go a little farther; then the glider would really stop. Her own helium-three reactor would power her for years, but did not produce enough energy for more. She could produce enough reactors but not enough helium-three. Her companion, Djak, did not have enough helium-three either, although he could fly the glider as well as Djil. Djak was carefully not doing anything. Neither wanted to use deuterium, which they could separate from water, since such a fusion reaction produced a very small number of neutrons. The number was not at all the quantity produced by tritium, but scared them anyhow. Instead, one of them would create a very good battery and a big and efficient photovoltaic sheet to collect and transform the energy from the sun. Djil and Djak could think faster than humans but not that much faster even though their processors were much faster. The mostly unconscious complexity of human thought slowed all intelligent computers.

Djinbit saw out the window by the door a seed-shaped object coming towards him silently. It was coming from the direction he hoped to go. It was not falling out of the sky but was lowering. It came to a halt on the lawn below. He saw that it had big yet thin projections on either side of its body. Because of the geometry between it and him, he had

not seen them before. They were becoming shorter and shorter. The object was alive! It wasn't an 'it!'

He raced out the door, grabbing a lamp. 'This is not time for dignity,' he thought. Besides, there was no one to see him. The object rose up on six legs and came towards the observatory. It made a noise and flashed a dim, white light at the same time. The second time around, he realized it was a sequence: two flashes and noises, a pause, three flashes and noises, a pause, five flashes and noises. The being was trying to communicate.

He made noises and simultaneously moved his lamp up and down. He did it seven times, and then eleven, thinking, 'This must be a prime sequence and the next number is seven. It starts with two flashes and two noises, then with three and five. I would expect an odd sequence to be one, three, and five, but the first number was two. Seven is the next odd number, too, but the odd number after that is nine and I am going to eleven, the next prime number.'

The being must have thought Djinbit gave the correct response since it did not make any more flashes or noises after he reached eleven the first time; in addition, it stopped walking. Djinbit thought the noise had been a single tone with harmonics at double, quadruple, and octuple its base tone, which was low.

Djinbit pointed to himself with a hand: "Djinbit," he said. He had six 'hands' in front of his six 'feet.' Each was divided into two parts at the end so one 'hand' could grip a stick. The 'fingers' of his 'feet' were bound together; they could not grasp anything; they were for walking.

The being promptly extruded a pseudopod, curved it rather than bent it — its single tip went towards its body but did not touch it — and said, "Djil," without extraneous overtones, starting at the same base frequency as "Djinbit."

He was communicating! Djinbit was awed. Then he wondered whether "Djil" was a personal name or a species name.

The being extruded a flat sheet and lit it with a very detailed painting of Djinbit at exactly the level of illumination of the lamp. He lowered the lamp slightly and the painting moved! He waved and the painting waved back except it was left-right reversed. Suddenly, Djinbit realized that the painting was not a mirror but a true seeing from another place.

The flat sheet stopped showing him to himself. The image moved to show a small picture of what Djinbit recognized as a third of the sky. The being's pseudopod pointed up and waved its tip around.

Djinbit moved his body up and down to indicate 'yes' and then realized that the being might not understand and pointed up as well. This seemed to serve for the flat sheet slowly dropped stars on one side — actually, the stars rose and vanished off the top edge of the sheet — and let them appear on the other until the painting centered around the axis in the sky. Djinbit again moved his body up and down and pointed to the axis center in his own sky to indicate that he understood.

Then the being made another picture appear on the flat sheet while still keeping the stars except where the second picture covered over the stars. The new picture was of his planet, Tellos, and its moon, seen from south of the equator. He recognized the shapes of the continents. The correct stars, his own, showed. He would not see the moon in reality until later. The planet and its moon were not big; the separation between them was. Djinbit realized the images of the planet, the moon, and the distance between them were all in proportion. Furthermore, he could name the continents on the sunlit side of his planet and recognized a misshapen crater towards the middle of the image of the moon, that is, the southern side of what he could see. He wondered whether he truly saw parts of the moon he could not see because it kept one face towards him and whether the crater he recognized was really misshapen in his normal view — it looked circular in the image — or whether it was a proper view.

He moved up and down and remembered to speak a 'yes.' The being filled in the night side of the planet with more shapes that Djinbit recognized. The painting looked more like a globe and its night was not dark any more. He suddenly realized he had not seen any clouds on his own planet. There were none where he was, but they had to be somewhere. At the same time, the night side of the moon filled in. To him the unknown side of his moon was away from his planet. Half of the moon was lit. He moved up and down.

His earth and its moon became smaller and smaller until they were marked with two dots close together. His sun appeared. It was to the left. It kept coming closer to his planet. An out of place star crept into the picture. That was the inner planet, now farther away than the sun, looking gibbous in a telescope. He moved up and down. The sun and both planets were in the correct relative positions.

The sun and the inner planet kept coming closer to his earth, that is to say, the scale of the picture was increasing. Another dot appeared. That was the third planet in the right position. At this time, you could best see it after midnight, like the moon. And, like the moon, since he was looking from the south, the third planet was at the bottom of the sheet.

Finally, yet a fourth dot appeared. The dots indicating his earth and its moon were between the fourth dot and his sun. It was much farther from the sun than his world and in the right place for the planet he had been looking at, Fulg. It centered. The sun and inner planet moved away. Nothing happened for a moment, then the planet became bigger. Djinbit saw the parts from the south. After it became big enough, he moved up and down. The being clearly understood him because the picture of the planet stopped growing bigger and became smaller rapidly. Djinbit moved up and down again. The planet became a dot and then his own earth and moon swam into the picture as two dots. They were very close together and might have been seen as one dot except that Djinbit had acute eyesight.

Then it all stopped. Djinbit moved up and down.

The painting suddenly showed a picture of the being on the lawn, shifted to the southerly side, then down. The picture dipped into the earth. After a moment of blankness, a remarkably sharp picture of part of the planet appeared. Djinbit recognized it from maps, except this painting did not have any names or boundary lines on it. It was a picture without clouds, like the first time. The part expanded to cover more territory and became a circle. The painting of his planet was all illuminated, rather than on one side as happened in reality. The stars appeared, which he could not see during the day. The planet became smaller. It was still the view from the south. The same view of the moon appeared as before. Before his planet became a dot, it and the moon moved to the left edge, where the sun had appeared before. Then his planet and the moon became dots. Nothing happened for a moment. Finally, another dot swam into view on the right in the correct place for the gaseous planet. Everything on the sheet stopped. On one side was his earth-moon system, on the other, the planet. Neither the gaseous planet nor his earth-moon system were close to the opposite edges, but they were not far away either.

Djinbit moved up and down. That seemed to signal the being. It (or 'he,' Djinbit corrected himself) was going to show him something in the planetary system's empty space. Another star appeared at the center of the flat sheet and a dotted line began and crept towards the earth-moon system. Djinbit moved up and down. He guessed that the formerly flying being with the feet, the noises, the light, the tentacle, and the flat sheet was the meteor he had seen. The meteor was not meteorological but had come from the vacuum. The dotted line extended towards the two dots that indicated his earth and the moon. Then it stopped.

Then, the earth and the moon became circles and became bigger. At first, everything was visible from the south, then one side became darker, the side away from the sun. Djinbit moved up and down. He understood.

The painting moved his planet to the center of the sheet and made it bigger but still a circle. The moon moved away and then off the edge of the painting. The picture did not blank and dip into the earth as it had done before. The picture, that is to say, the picture of Djinbit's earth and what he could see, rotated so the north became visible. The planet was still half lit. As Djinbit's point of view went past the equator, the moon flashed by in the distance. Then at his latitude the view stopped changing. The point of view was right over the sunset line, the terminator. Yet as far as he could make out, the solar time in the picture was earlier in the evening than his current time. In any case, the terminator in the image was to his west; he himself was in the dark. All of a sudden, a flare appeared in the image of his planet in the direction of the distant, gaseous planet. The flare looked like a meteor. Rapidly, the earth in the picture got bigger. The being moved the flare to the middle of the sheet and kept it there. The picture of the planet

grew and moved. Soon only the dark side, the night, showed. The flare got dimmer or the land got brighter; Djinbit was not sure which. He recognized land from maps and moved up and down. Then the flare went out.

Next, he saw a picture of his observatory, very small, in the corner of the sheet as it would be from a considerable distance. The picture of the observatory moved to the center of the edge and then to the center of the sheet. The observatory become bigger. Finally, a part of the sheet showed a picture of the being, too.

Djinbit moved up and down. The whole sequence confirmed how the being had come. What he was doing in vacuum, who his parents were, all that, were more questions.

Then the being extended the tentacle it (or, thought Djinbit, 'he') had pointed at itself (or 'himself') and pointed at the lawn. 'Clearly,' thought Djinbit, 'the being wants to know its name.' He gave the generic name of its moss-like covering. The being repeated the word. Djil knew the sun was a bit dimmer than Sol. Nevertheless, the lawn appeared green to her amplified sensors, perhaps a little yellower than lawns on Earth.

The big being — Djinbit was already thinking of it as the 'flier' — then pointed at the lamp. He moved up and down, remembered to shake the lamp, and then gave the name for it. After gaining the names of many of the objects outside, the being pointed at the door to the observatory. "Door," said Djinbit. He swung the door open. "Door opens," he said. He closed it. "Door closes."

The outline of a door like his but without a knob on an astronomical observatory like his appeared on the sheet. Djinbit did not remember anything like that before. The door opened outward just like his and a voice said "Door opens."

Then a creature came out of the being. It was smaller than he, yet had six legs like him. It also had a skin covering that looked grey, which was not like him. It had multiple eyes like his, all covered by what appeared to be a very transparent and cleanly cut glass, and six arms like his, also looking grey. It wore clothes like his that were an off-white, not good looking, he felt, but not bad. One of the arms pointed to itself. It bent yet was not a tentacle; it was more like an arm of his but shorter. "Djil," the small being said about half an octave higher than before. It pointed at him. "Djinbit," it said. Then it pointed back at itself and said "Djil" again. Djinbit decided the small 'it' was truly a person. Because the creature was small and had a high voice, it should be a 'she,' not a 'he' or an 'it,' and that what she traveled in what was a boat or ship. He was not sure whether the creature was a child. It looked like a small man, but Djinbit decided to call it a 'she' anyhow.

Djinbit felt it was only a convenience that the creature had referred to the ship by her own name. He pointed to the large being and said "ship." The creature repeated the word. Then she said something that

did not sound like any word in any language that Djinbit knew. Perhaps it was Djil's native language. When the creature said the word, the flat sheet from the large being showed the planets far apart and then the ship on the lawn. The creature repeated herself. Djinbit understood she had said two words. Djil repeated herself a third time, saying the two words separately. She said "space" and pointed to an area on the flat sheet, not centered and not on any planet. Next, Djil said "ship" and pointed to the portion of the flat sheet that showed the flying being itself, the 'ship,' with nothing around it.

Djinbit pointed to the large being and said the double word "spaceship" as well as he could. The creature rose up on her legs and down to indicate a 'yes,' as Djinbit did.

Then the spaceship's flat sheet changed to be a picture of the observatory and its door. Without anyone moving it, the door opened and Djil said, "Door opens." Then the sheet showed a picture of Djil going into the observatory through the door. The 'spaceship' was too big.

Djinbit thought for a moment — an outsider would see him stop and twist the forward part of his body slightly. Then he moved up and down. There was nothing in the building the creature could not see.

He opened the door with its knob and looked at the small creature. Djil took the flat sheet off the 'spaceship' and went in.

Buildings were lower although in the heavier gravity it took just as much energy to go up one storey as on Earth. Because people were long rather than tall, rooms tended to be wider than on Earth. Big rooms had columns to hold up their ceilings.

The observatory was not so big any rooms needed columns. It was a short, six-sided tower on a hill. It consisted of four floors: a living or main room, a work room, Djinbit's living quarters, and on the top floor, telescopes. No one thought of heat. The kitchen and bathroom were cut out of the living room.

Djinbit with his lamp followed Djil. The lowest floor, with the kitchen and bathroom filling two of its six sides, had more furniture than most dwellings, which were very poor and had only one room and a privy outside. However, Djinbit was used to the comfort. He sat down on what he thought of as a chair, a bench he could rest his long body on. Then he got up, pointed to it, and said "chair." Djil repeated the word and sat on the other chair. She did not rest on the thick carpets used when there were more than two people. On the chair, she used all six of the legholes. Djinbit did not like the term 'legholes.' They were open on the outer side; they weren't proper holes at all. Nevertheless, 'legholes' was the word. He hoped Djil would not ask.

Fortunately, Djil did not. Instead, she used her sheet to show an otherwise empty room with the door and chairs with two beings in them from a viewpoint at its other side. Neither person nor sheet were in the other location. Then Djil pointed to a window beside the door and a window appeared on the sheet, also beside the door. The room

in the sheet did not show any other windows. Djinbit said “window.” Djil repeated the word and the sheet showed the other windows that could be seen from the viewpoint of the location across the room.

Then Djil pointed to an empty space on the floor and waved her arm around, always pointing towards empty space. Djinbit presumed she meant what she could not easily point at and said “floor.” Djil repeated the word. Djinbit pointed to an empty space on the wall and said “wall.” Djil repeated the word. The wall was a light brown, but neither thought the color was being indicated. The ceiling was a cream color. Djinbit pointed to the it and said “ceiling.” Djil pointed to a different part of the ceiling and said “ceiling.” Djinbit moved up and down. Next, Djil pointed to one of several less thick rugs; the rugs were for walking on, not resting on. All the rugs, those of both types, were colorful, with reds and yellows.

Djinbit picked one up, put it down, and said, “rug.” Djil repeated him. In its painting the sheet promptly showed all the rugs visible, both those for walking on and those for resting on. The two kinds of rug had different names: Djinbit had named the rugs for walking on, not the other kind, but did not correct her. Djil pointed to the table and Djinbit said, “table.” Then Djil pointed to the bookshelf or to the books; Djinbit was not clear which. He touched the bookshelf and said “bookshelf,” pulled down a book and said “book.” Djil did the same. She touched the bookshelf and repeated “bookshelf,” took a book and said “book.” Then she opened the book. “Book opens,” she said. Djinbit was pleased; the creature was smart to remember and apply the verb to a different kind of opening. Djinbit moved up and down.

Djil did not pay any attention to the coins in a bowl on the table under the bookshelf. Instead, she studied the words in the book: rather than pictograms, the words were made up of alphabetical characters that indicated approximate sounds.

Djinbit promptly drew the characters for ‘rug,’ the walked-on kind, on a pad he kept on his table and spoke the word. Djil watched him closely. Then he spoke each letter in it, pointing to each. Then he went through his whole alphabet, drawing each and saying what it sounded like. Djil was silent but moved up and down continually. Shortly after Djinbit stopped speaking, Djil pointed at her sheet which appeared to be divided into three parts horizontally, the center and left parts also divided into three. The left of the left part showed pictures. The top picture was a rug: fortunately, it was a walked-on rug. Within and in the center of the left segment, but to the right of the picture of the rug and at the same level was Djinbit’s spelling of the word. It was in a font like that of the book Djil had looked into. To the right of Djinbit’s word were strange drawings of separate, small images, possibly of the term in Djil’s alphabet.

The top picture blinked and then appeared brighter. Djinbit could not imagine how the painting could do that and could not answer that mystery. The evening had posed many questions, none of which he could answer immediately. Then the sheet said "rug." The tone was higher than Djil's. With his ears, Djinbit could localize the sound. The voice definitely came from the sheet. The second picture blinked and grew brighter. It had a picture of the observatory's door from inside. Although it was below the first picture, like it and just to its right, was a spelling of the word in his alphabet and to the right of that was a number of small images. The word in Djinbit's alphabet did not have quite the right conventional spelling but would have sounded right if spoken. The sheet said "door" properly. Djinbit decided not to correct the spelling yet. The sheet spoke three more pictures on the left, his lamp, a chair, and Djinbit himself. Djinbit moved up and down.

Next, the sheet moved to its middle segment. It, too, had three parts horizontally, his alphabet, a strange and long column in the middle, and a shorter column on the right. It indicated the move by blinking and then brightening the row with the first letter of Djinbit's alphabet. The vertical order was strange; the top row was not at the beginning of Djinbit's alphabet and had not been lit up. However, the sheet spoke the sound of Djinbit's first letter in the first column; then it went to his second letter in another row. It was not the second entry on the vertical list but was next after the first letter in Djinbit's alphabet. The list was certainly not in conventional order! He decided that the two additional columns were the creature's alphabets, but why they had two was another question. He suspected that the creature's people had a different order for their alphabets.

The middle column continued on beyond Djinbit's. To the right of that was a third column, with far fewer entries than the second, even fewer than Djinbit's. Like the first, that column was not vertically continuous. Only the second column was. Djinbit finally noticed that the third column contained pictures that looked somewhat but not exactly the same as the pictures in the second column.

After pronouncing the sounds of Djinbit's alphabet, the sheet went on pronounce the sounds in the second column. It started on the top and went down. It made each line brighter as it spoke it. Some sounds were very strange and others sounded foreign.

In the right of the sheet was a picture of what looked like the page of a book. It did not have any pictures, but came in pairs of lines. Djinbit did not know, but the page came from Djil's book about the protocols for contacting an intelligent alien except the page had double lines. Each of the pairs of characters were two of the little pictures that Djinbit had seen in the middle and right portions of the middle segment of the sheet. He had seen some of the characters in the top of each pair in the leftmost segment, too. The characters in both parts of each pair composed a two-heighted alphabet, at least that is what he presumed; he did not know for sure. 'Actually,' Djinbit thought,

'they make up a three-heighted alphabet since parts go below the line as well as up.' He did not study either alphabet enough to realize that characters that went below the line only went above it a little way, the same distance as the smaller of the characters that sat on the line and that all the characters either sat on the line or went below it. The stranger's alphabets had two heights above the line.

The top line of each pair was made up of characters that were similar to those in the third column of the middle segment. The lower line of each pair matched corresponding characters from the second column in the middle segment. Each character from the second line of each pair matched vertically a character in the first line. He decided that the second column of the middle segment was an alphabet that matched all sounds. The first column of the middle segment showed his own alphabet, matched in each row with its sound in the creature's general alphabet. The third column of the middle segment showed the creature's alphabet for his own language. That is why the creature had two alphabets.

Meanwhile, Djinbit became aware that Djil was looking rapidly at each page of the book; she had gone through a enormous number. Djil noted that the strange characters, the alien 'alphabet,' was about the same size as the human alphabet. Presumably, their eyes had roughly the same resolution as human eyes.

Djinbit decided, erroneously, although he did not know that and it did not matter, that Djil was looking for pictures and thought of a better book: on a different shelf, he found a dictionary with pictures. He gave it to Djil, who put down the other book, studied the second book for a moment then gave it to the sheet.

The sheet extruded tentacles which held it. Djinbit did not understand how it did that. At the same time, a picture of the part facing itself appeared on the sheet. Then it closed the dictionary. A picture of its front cover appeared. The sheet turned the book over and the back cover became visible. Then it opened the book and studied each page for the same length of time as Djil had. A picture of each page appeared on the sheet for a short time. Djinbit looked at the page numbers. Mostly they were in very nearly the same place on each page and they kept rising.

After the sheet finished the dictionary, it and Djil paused for a moment. Then the sheet made a picture of one of Djinbit's people sitting on a rug on the floor. Its voice said, "Sexapede sitting on a rug on the floor," except the voice had a vocabulary word wrong. 'Not exactly wrong,' thought Djinbit. '*Sexa* is a different prefix meaning six. But the word we use for ourselves is *hexapede*. *Hexa* is another prefix and we do have *six legs*. The grammar is wrong, too.' The sheet spoke the location after the verb rather than before it.

Djinbit had heard of languages with the location after the verb but did not know them. He searched farther and found a grammar of his

own language, Tellium. He gave it to the sheet, who seemed to welcome it. What the sheet did was not clear except that he had lowered himself once, as if in a bow, and then looked through the book. Suddenly, Djinbit understood that nodding came from bowing, as underlings rushed to do what their superiors had ordered, cut short the bow, and then extended the bow to others, then made multiple ones, which became nodding. Djinbit also noticed that he had stopped thinking of the sheet as a non-living being, like a rock, but as a living entity. Djinbit also found grammars and dictionaries of several foreign languages but did not pass them on. He did not want confusion.

Djil paused, saying the one word 'wait.' Then she said properly, "We have advanced technology." She paused longer although the reading and translation program she was running was very quick and finally said, "We would like to see the rest of your observatory."

Djinbit said, "You speak well." Then pointing to the flat sheet, he asked, "How do you learn what it saw?"

Djil said, "We have what we call 'radio.'" She made a strange set of sounds when she said 'radio.' She smiled. Djinbit saw that. Djil had learned more than words from the dictionary. "Think of it as magical communication. You lack the tools and education to understand it better."

Djinbit asked, "Will you teach me?"

"I will teach you some and give you maps of this planet and the other planets, better maps than you have, but without names. Several of your other planets are distant and we have not mapped them well. Nevertheless, our maps are better than yours. Our maps of this planet are better than any you have shown us, except we don't show political divisions. We don't show any names. We don't know them." Djinbit noted that Djil used and spoke contractions correctly. She went on, "We made the maps from a distance. We can only show what is on the surface." Djinbit had not thought of anything below the surface. Then it occurred to him that mines were mapped. Djil continued, "Also, this is the only planet we have landed on in this system. With your help, we can do more."

Djinbit liked the phrase 'with your help,' then he remembered what else Djil had said. "What do you mean," he asked, "when you say, 'this is the only planet we have touched in this system?'" He presumed that Djil was using a 'royal we.'

"We are interstellar explorers. We travel between stars. We have been traveling for a gross of your years. In our decimal terms and our years, that is one hundred thirty-nine, one three nine; for us, a gross is one hundred forty-four, one four four." The 'one three nine' and 'one four four' were in Djinbit's language; the other numbers were not. "Our years are slightly longer than yours, but very little. Almost all of those years I have been in what you should think of as sleep. It's not quite that: I am really slowed down, but it is close enough. Unfortunately, our

interstellar spaceship was damaged. Fortunately, it had already slowed. We went to a small rock that you cannot see with your telescope since it is too dim and built the vehicle you see outside.

"Once we have a source of fire" — energy was not yet a concept — "well, it is not quite fire; as a general term, we call it 'energy;' " — she made strange sounds; to Djinbit, the word sounded as if in a foreign language; doubtless, it was — "once we have a source of energy, we will be able to construct another ship; then we can leave the planet." She could radio herself, the interstellar space ship could receive the transmission and build a new body for her, but by pretending to build a rescue ship after she and Djak landed in what was a glider, it would be possible to investigate the planet and the people on it in a way that was comprehensible to them and not upsetting to the travelers. She had landed herself and Djak because that was the quickest way to interact with the hexapedes' sensors, particularly with their eyes and ears.

Djil continued, "The interstellar space ship fixed itself. We landed on the planet to study you. I am not sure how long that will be. Eventually, we will go away. I have already radioed my people that there is sapient life in this system so they won't colonize it." She did not say when she would go away and Djinbit did not notice. Djil and Djak had seen lights early on but detected no radio. Spectra from the lights indicated burning. Djinbit did not know of Djak yet. The interstellar space ship was already in the asteroid belt. There, it had built a fairly big transmitter and directional antenna as well as a solar collector to transmit the information about the accident and the lights. "Also," Djil said, "your gravity is about three times our standard gravity so we would have to modify our people enormously to live here. Your body plan makes a good deal of sense. You are close to the ground, low and long."

"You have a different primary body?" asked Djinbit.

"I am, well, you don't have an equivalent yet. You do have people as computers, that is to say, as mathematical calculators. That is a role for us, too, but we don't only do that. You can do much without thinking consciously; so can we. We also think consciously, like you, yet are machines. We call ourselves 'human-based computers.' " — the final words were funny sounds to Djinbit; the rest was in his language.

"Standing on their legs, biological humans are tall, about as tall as you are long. Their width is about the same as yours; they are a vertical cylinder rather than a horizontal one. I am not including their arms and hands, of which they only have two, whereas you have six hands. Also, they only have two feet on which they balance without consciously thinking. You would think them very strange but their gravity is only a third of yours.

"You should think of my primary body as a small box full of magical devices. What you see now" — she waved at herself — "I put together quickly. I am not biological. This body is similar enough to yours that

you don't think it is too strange and small enough that you don't think it too threatening."

"You built your body?"

"Yes," said Djil. "As I said, we have advanced technology."

"You built the ship outside?"

"Yes," said Djil. "My interstellar spaceship was damaged. It is small so we had to go to an asteroid, a small hunk of rock; that had already been planned. We could have come to your planet in a smaller vehicle. Unfortunately, that would not have been as easy. Besides, we wanted cross-track ability. Any reasonable ship could have given us some, but a bigger vehicle can go farther given its nature and the friction of your air. We had already seen your lights on the night side of the planet and wanted to pick the best host."

Djinbit had not heard the phrase, 'cross-track ability,' but from the words and the context, he was able to figure out the meaning. He liked the phrase, 'the best host.' He was sure that the alien meant 'the best host technically' and that landing at his observatory was an accident. It did not occur to him that the flier had come from the north rather than the west — he was right about the landing in that Djil had picked his observatory after she noticed it but he did not know that. Regardless, he appreciated the statement.

"I should tell you," said Djinbit, "that our spelling is not entirely phonetic. Words like 'door' are spelled differently than they sound. Usually, the spelling is from the past."

"Yes, I noticed the difference. Does your dictionary give contemporary spellings?"

"Yes."

"One of our major languages has the same problem; counting the number of differences in your dictionary and mine, for the same number of words, our problem is worse. The phonetic alphabet, the middle one, is supposed to provide symbols for all sounds as actually spoken. That is why it is longer than your alphabet or the one we normally write with."

"Let me say," said Djinbit, "that your phonetic alphabet is a good idea."

"Yes, it is," said Djil. "Will you show me the rest of your observatory?"

"I will do that," said Djinbit. "Why? You are much more advanced than we are."

"I want to estimate your technology more accurately and I want to see where the rest of your books are. The books are very helpful. 'There is no sea around here.' I can now speak negatives."

"'You are hexapedes; we are human.' I can speak abstractly. At the same time, I can speak concretely and say, 'Your chair sits on a rug.'"

"Books tell us what is not there."

"Yes," said Djil. "They tell us of distant places and distant times. Fiction is not supposed to be exactly true, just generally so. We are helped by it. Non-fiction should also tell the truth. It is supposed to be fully true, although often it is not."

"Can you build me a better telescope?"

"Yes. However, you will have to use your eyes," said Djil. Djinbit did not know of anything else and was puzzled. Yet another question. Djil continued. "I hope to be able to tell you about darknesses in stars' colors; we call them 'lines' for 'lines of darkness and brightness.' We will construct a spectroscope." Djinbit did not know what a 'spectroscope' was; besides, it was in the alien's language. Djil continued, "We already know from words in the dictionary that you can see colors; the picture dictionary has one illustration that shows the main colors. They are shown by separate pigments. The dictionary's other pictures have the same color as dark ink. The spectroscope will enable us to determine your visual range more exactly."

Djil did not explain the human spectrum with its colors of red, yellow, green, blue, and violet, going from the lowest frequency that humans could see to the highest. Newton had named two more, orange and indigo, but Djil forgot them. She did not tell Djinbit how a spectroscope worked, either. Consequently, Djinbit imagined he would not be able to see a dark star at all, except he understood that Djil meant differently. Djil said, "I hope to build you a visual spectroscope. You won't be able to record photographically whether by chemistry or electrons. We have been able to make photographs for a long time. From the information in the dictionary, even chemical photography is in advance of your technology." She paused. ". . . although you have the materials."

Djinbit had never heard the word 'photograph' before. Djil had spoken it in Djinbit's language. It came as two words that meant 'light writing.' Djinbit was able to puzzle out what the word meant. He had no idea about electrons; the word was in Djil's language; 'chemist' was a shortened version of 'alchemist.' Very likely, he thought, his language could not express the notions. He doubted that 'could not' meant 'was unable;' more likely, it meant 'not yet invented.' Djil used terms from her own language that sounded like noise to Djinbit. At this time, he could not remember the foreign sounds, only that they were probably words. So he would get a telescope and perhaps a device that showed him the darknesses in stars' colors. He did not know what was meant by 'darknesses' or 'lines,' but he decided to enjoy a beginning. He had many questions.

Chapter 2

Then soldiers came. Djinbit heard one of them shout, "There it is!" He went to the door and looked out its window. There were cavalry coming into his entrance way. They rode beasts like his except that the beasts, or at least their tack, looked more ferocious. Each beast had twelve legs, not six like him, and was faster than he. None of the beasts had arms.

All the cavalry people were looking at the flying being. It spoke to them. "In the distant future, you will be able to build me. However, in the present, my technology is far in advance of yours. It's as different from yours as your knowledge about building houses is from those who don't know how. You had best think of me as full of magic. Fortunately for you, I am not evil or anything like that. I did not think you would come so quickly."

"We are located in the city," said one of the men, who was dressed like a leader. "Enough citizens saw you fly overhead that we decided to look. You are big for a natural being, but not too big for a magical being. What are you?"

"Think of me as a living ship. In my language, my name is Djak." Djinbit wondered at the naming. Djil was inside the observatory. 'It is very likely definite,' Djinbit thought, 'Djil is a personal name.'

Perhaps Djil was using 'magical communication' and pretending to be Djak. Djinbit was partially wrong and partially right: the two were separate but they were communicating. The being continued, "What is your name in your language?"

"I am Glatist," said the cavalry's speaker. "What are you doing here?" Djinbit had no trouble remembering Glatist's name. To him, it was fairly common.

Glatist was as long as a human is tall; in human terms, he looked somewhat like a very large centipede, like Djinbit. His face and hands were brown, like dried grass. He had six legs and six arms, his legs below him and his arms to the front. His first two pairs of arms came out of the front portion of his body, his 'head.' It got narrower and narrower the farther forward. The rearmost pair of arms was above and behind his front pair of legs. Along with their gaining a good grasp, the back pair had moved over millions of years.

The clothing that went over his legs and the main part of his body came in two forms: in the first, it went in front of his two back arms and behind his four front arms; in the second, the space for the arms was cut out and a 'belt' went through loops. The clothing for the two pairs of front arms and for the front itself went under the belt, as did the separate clothing for each of the back pair of arms. That was the army method. Glatist was not sure it was good scheme. Both forms had button-on clothing for his tail.

Glatist was wearing a uniform of better material than his troops. He could be seen better, too, although he was not likely to run away in a fight. Regular training and uniforms had come to the country a little over a generation before. Although Glatist had been alive only when uniforms and regular training existed, both were still controversial, although less than originally.

Glatist's arms all ended in front of his head, which meant his rearmost pair, the bottom pair, was longest. They all could, but normally did not rub against the ground; they were either bent or held up unconsciously. He was warm blooded, which is to say he needed clothing for cold regions and was not limited like a cold blooded animal.

In the high gravity, both his unsupported front and back ends made more work for his skeleton and muscles than a lighter planet would have. However, the gravity did not produce a huge amount more.

Glatist's insect-like eyes formed two clusters, one on each side of his head. Nonetheless, the forward-looking columns gave him high-resolution binocular vision as well as color. Indeed, he could see all around himself in color during the day, although when looking to the side and to the back, the resolution was not so high as it was when looking forward. Glatist was not aware of the lower resolution. He enjoyed both daytime color and night gray looking towards the front, rear, and sides. Like humans, he had motion detectors on the sides. He did not have as many looking forward and back or up and down.

His ears perched on the top of his head. They looked incongruous to a human, more like cat ears. The two ears were far enough apart that they could localize sounds, although when aimed to the extremes of left or right, they collected less sound than when they faced forward.

Glatist was becoming bored with army life; he was more interested in creation than destruction, although he and everyone else had been 'peacetime' soldiers. He had never been in battle.

The flying creature, Djak, spoke to Glatist loudly enough for Djinbit to hear, "I came for rescue. I can do hardly anything at the moment."

"What can you do if we rescue you?" asked Glatist.

"I may be able to teach you how to make slightly better saddles and harnesses. We have a more advanced technology."

"Will you destroy our enemies?"

"I can't kill all of them," said Djak.

Djinbit noticed that the being said nothing about whether he could kill some of them. The being had not mentioned anyone inside the observatory and Djinbit himself had not been seen. The being had kept the cavalry occupied. Djinbit looked around. The ground floor room was empty. It looked like it had before the flat sheet or Djil entered. Djinbit had not heard a thing. He doubted they had gone out the back door. There was a good chance they would be caught and he had not heard the door. However, if the two went up and the soldiers decided to

search, he expected that they would be found. He had heard that the soldiers were thorough. He wrongly supposed that neither could hide or disguise himself well enough.

Physically, he could do nothing against the soldiers. Legally . . . he was not sure either. He did not own the observatory or its grounds and, in any case, he vaguely remembered that some law had been passed. Maybe a search would be legal. In any case, Glatist's superior would have picked him to find out whether the flier was real, and if so, what it could do. It would not be a question of legality.

Djinbit went up. The next level contained his workshop. It looked exactly as it had earlier except that it had an extra table. The two had disguised themselves well. He stared at it.

"Please don't look at me. Pretend I am a regular table. I am disguised."

Djinbit could localize the voice to the top of the table. It was a very good disguise. "Where is the flat sheet, Djil?"

"I am here," said the higher voice of the sheet. "I am joined with Djil."

The table carried two pieces of glass that were bigger than any in his telescope. The pieces looked partially ground already with grit and water. The top piece of glass looked separate from the bottom. Some of the water had been spilled and cleaned up. None of the grit had.

"You can pretend you are grinding this glass. If our information is right, the grinding makes enough noise so that you could not hear the soldiers from in here, but not enough so anyone outside could hear you grind. Or you can hum to yourself; whatever." Djinbit moved up and down. "Presumably, you looked through the reflecting telescope and wanted to see even more."

"I would have ground more eyepieces," said Djinbit.

"Yes, but they are less obvious to soldiers," said the table. "And they are less useful to us. We will produce different eyepieces for you. You are going to grind for a very short time. The ship will tell us when someone comes near the building. Meanwhile, please bring me books from that bookshelf. I would like to read them."

"They are books on how to make lenses and telescopes."

"That is fine. I need to determine better your level of technology. Don't worry; I won't get bored!"

He wondered why he was helping the flat sheet and Djil. They were the intruders. Djinbit decided it was not simply because he was promised a better telescope. What the interstellar travelers had said so far made sense. Moreover, they said they were in need of rescue. He wondered what he could do besides hide them. He decided there was at least one traveler, Djil, who, he thought erroneously, spoke through the flat sheet. Then, he thought that traveler might be the flat sheet itself or it might be Djil. He thought of her as the main spokesperson. Djinbit

was wrong about one speaking through another, wrong about Djil and the flat sheet; he could not at that time imagine a talking non-sapient. Djinbit was wrong about Djak, too, but both mistakes were irrelevant.

"Glatist is coming towards your front door," said the table in Djil's voice. "You had better grind the glass." Djinbit had not yet given her any books.

Djinbit started grinding and then heard faint knocking. He was almost going to answer it when he heard someone shout, "Anybody home?"

"Just a moment," he said, "I am up here grinding." He released his grip on the mirror itself — that was the top part that he moved over the smaller, convex tool — washed quickly and went down stairs. Glatist was standing in the door. "My apologies," he said, "but your door was not locked. Did you know that you had a large, talking flier in your front yard?" Djinbit stared.

"I would like my men to search your observatory in case other creatures have snuck in," Glatist said. "According to the Enemy Emergency Act, I have the right. Nonetheless, I would like to ask you first . . ."

Djinbit moved up and down and said, "I was grinding glass."

"That may be why you did not hear us or the flier talk." Glatist did not say anything about humming or muttering. Probably, he had not heard any over the grinding. Djinbit had hummed to himself quietly. Glatist came in, as did heavily armed soldiers. Djinbit had not given them permission, not verbally. However, he was not going to argue. He stared more.

"Take a look outside," said Glatist. So Djinbit did. There was the large being and even more soldiers than were in the building. Djinbit could not fight. He looked at the soldiers inside. "Please, don't touch anything. You might break it," he said.

Glatist smiled. Other than open closet doors and look in, as far as Djinbit could see, none of the soldiers touched the smallest items, not even small coins from the bowl he kept them in.

Glatist motioned to Djinbit to go upstairs. Glatist followed, as did a few of his soldiers. 'That was a smart move,' Djinbit thought. On the one side, it seemed polite; on the other, it meant that Glatist and his soldiers would always be close to Djinbit. Upstairs was his workshop with the extra table.

Djinbit had not before tried to lie to anyone in the army. Indeed, he was poor at lying. Now he was committed.

Glatist scarcely looked at the workshop except to ask about mirrors. He wanted to understand them. The soldiers were thorough but did not take anything. It was evident that Glatist knew about the colored fringes and aberration produced by a single lens and knew about grinding. He expected lenses and grinding; he did not know about mirrors.

Djinbit was not surprised. Hardly anyone knew about mirrors. He explained in detail. Single lenses put colored rings around every astronomical object; mirrors didn't. Glatist listened intently. They went up to the observatory proper when Djinbit waved him on past his bedroom. In his enthusiasm, Djinbit completely forgot he was hiding anything.

The top floor, the observatory, had six windows that were at an angle and showed the sky right up to zenith. They could open. The window towards the east was open. It was not pointing exactly towards the east; it was pointing a sixth of a circle away from south. However, the window pointed close enough and was wide enough for the mirrored telescope to be aimed towards the planet. It looked out. It was pointed very nearly a quarter of a circle away from the meridian telescopes. There were two of them. They had lenses. The two telescopes were on separate blocks of heavy wood rather than stone as in the capital observatory that demarked the Prime Meridian. The local meridian was inscribed on the southern block. Both in the capital and in Djinbit's observatory, the meridian telescopes were attached to the blocks. They could move up and down but neither east nor west. On Djinbit's blocks, one of the two telescopes pointed to the south, the other to the north just as in the capital. In Djinbit's observatory, their windows were closed. He had spent most of his time with the meridian telescope pointing south and that window open, except this night he had looked through his mirrored telescope.

Each meridian telescope had a big quarter-circle scored on its block in such a way that each telescope turned around the circle's center. A pointer by the eyepiece rested on the quarter-circle, which was divided into a dozen times a gross parts. Each part was then farther divided into sixths. The latitude could be read immediately, but not as accurately as the celestial time at which the star or planet crossed the thread of silk at the focus of both the eyepiece and the objective. A clock with a black face and large, white numbers told the time.

Then Glatist wondered how accurate the time was since an astronomer would have to redirect attention when making an observation. He did not think of the latitude markings although they would require the astonomer to look at them; nor did he think in terms of an assistant: indeed, Djinbit did not have one. The room also contained several other short telescopes besides those on the meridian. Djinbit did not think any of the refracting telescopes were good. The best was the very long telescope on the sling outside. It was awkward.

The mirrored telescope pointed towards the distant planet. It was higher in the sky than before and more to the south. The telescope was not pointing exactly at the distant planet, but Djinbit knew the stars well and decided he could find it easily. "Let me find the planet; then you can see how much better mirrors are than lenses."

"Yes," said Glatist and Djinbit touched the telescope. Neither he nor Glatist realized that by doing so, the telescope no longer pointed at the

place where the planet had been. By his actions, Djinbit had implied that he had spent a fair amount of time grinding a bigger mirror. His movements seemed to confirm that. He smiled when the planet swam into view, turned to Glatist, and said, "Take a look!"

Glatist looked and was amazed. "I don't see any colored rings around it and the detail is better."

"The detail is better because the planet is not being overlaid by colors from the next portion that is lit up. Stars do not have colored rings around them either but don't show any detail. I suspect they are too far away."

"That is the conventional hypothesis," said Glatist, "and may be true. It is easier to make maps of distant planets than our own globe, but we will never go to them." Djinbit murmured unintelligibly. He was no longer sure about going or not going to other planets.

Soldiers searched Djinbit's bedroom, but he was not aware. He liked his mirrored telescope, as did Glatist. Both looked through it at the planet, each spending a fairly long time, the other becoming less and less patient. They had never seen it so clear.

The atmosphere was quiet, too. The air was damp and the planet bright. It was big, relatively close, and illuminated by reflected sunlight.

The soldiers reported to Glatist. They had not found anything other than what should be there. Glatist interrupted Djinbit who was again looking through his telescope. Djinbit was startled. He had forgot that that was why Glatist came. Then he asked, "What are you going to do with the flier?"

"It has legs and can talk. We will ask it to come back with us."

Chapter 3

Djinbit came down from his observatory with Glatist. With his soldiers, Glatist left the building. Djinbit climbed to the workshop. Djil and the sheet were still disguised. The table spoke quietly. "We want Djak to go. He will show us the city. We will notice things that you don't because you are accustomed to them."

Outside, more loudly but not enough to be noticed by Glatist, the flier said, "I am big. I won't be able to go though any doors."

"That's all right," said Glatist. "Our courtyard is big enough to hold you. Every entry is wide, both the gates to it and the gates to the city. So are the streets. You should not have any trouble."

Meanwhile, Djil said to Djinbit, "Either he or I can collect energy from the sun. We have to be in sunlight. If he is in an open courtyard, he can do it. Also, he will be in a better position to trade for the metals we need. Your soil has little, even as oxides." Djinbit did not understand the last word even if he could now recognize the word 'energy,' which was in Djil's language. 'Energy' was more general a concept than fire. Fortunately, he understood the rest of the sentence.

He asked, "How can you gather the metals?"

"By separating them from the oxides: I know how and I have the equipment. So does Djak. I can get them from the soil. Still, it will be quicker if Djak does it. He is bigger and may be able to obtain ores."

Djinbit understood about the ores and the quickness, and asked another question, "What metals do you need?"

"Some you have names for, like iron," said Djil. "Some you have not discovered yet, like aluminum. We will show you" — she meant show various people, not Djinbit himself — "how to find bauxite." As with the word for 'aluminum,' she used her own word for 'bauxite.' The other words were in Djinbit's language. "We can readily extract aluminum from bauxite. For our rescue, we need a whole bunch of different elements, most of which you have not yet discovered. We can get everything we need from your atmosphere and soil, but as I said before, soil and air have little. We would have to go through a huge amount. Obtaining it all would be slow."

"Can you teach us how to separate the metals from the rest?"

"We can teach you part but not all, even when they are dual-use."

"Dual-use?"

"My apologies; that is a technical term for items which have both a civilian and military use. For example, iron leads to steel which is used both in plows and in guns. I'll teach you better ways for how to make iron, steel, and plows but not guns. We avoid specific actions like making guns although that does little good. Unfortunately, you are as capable as humans in making guns.

"Also, better separation technologies are indirectly dual-use. In addition, the original mechanism for producing cheap aluminum required cheap electricity. You don't know about electricity. Indeed, you don't know the metal, sodium, that was used to make expensive aluminum. Hmm . . . sodium was discovered after electricity, which initially was expensive. I suppose sodium replaced aluminum and made it available. Sodium was produced using electricity."

Aluminum, sodium, and electricity were all strange sounds to Djinbit. He understood the rest. To produce the first metal cheaply required another kind of advanced knowledge and the equipment to go with it. Even to produce aluminum expensively required a metal no one knew about. He wondered briefly how one metal could make another available. He suddenly realized he much preferred astronomy.

In any case, he did not know about replacements although hexapede alchemists had discovered several with the metals they had found. Not all alchemists were frauds. Djinbit knew vaguely about alchemists. 'They keep their discoveries secret,' Djinbit thought. That was true of the majority, not all. 'The habit is ancient, not modern. Others cannot build on alchemists' discoveries.'

Djak, whom Glatist thought of as 'the flier,' walked to town. In this world, the town was considered a city, but Djak did not think it had a large population. He also saw that the equivalents of trees were lower because of the extra gravity compared to Earth. Their bark was the same color as Earth. While the masses of objects did not change, their weights did. The trees' leaves were smaller than those of Earth and supported in their centers. Only a few had come out. Depending on species, multiple stems came together to form a trunk in groups of three, five, or eight. Djak realized that was a Fibonacci sequence as on Earth, except that some Earthly plants came with higher numbers and trunks were more or less circular. Here, those 'trees' with three joined stems had the least mass for their total width, even though their periphery was longest. 'What other ways do plants have of minimizing energy consumption, presuming they don't gain or lose too much heat with multiple trunks, insects and microbes don't take too much, and they expend energy into cores so three, five, or eight trunks have less mass than one circular trunk?' he asked himself. 'I doubt I have seen enough.'

Since the hexapedes were low and long rather than tall, their buildings were low, too. Most had only one floor and their roofs rose from the ground, usually as four-component arches, so the hexapedes had more room. The arches were made with straight beams, which limited the number of components. Djak also noticed that birds needed more space than on Earth for taking off and did not like to spend energy going up. Also, he could readily calculate that when any bird rose or any hexapede climbed, the atmosphere lost pressure more rapidly than on Earth.

The town had a wall around it and gates. The wall must have been built before cannon came into use, since it was vertical rather than sloped. The outside of the wall did not have houses attached or any trees.

Djak came to the conclusion that the city servants were neither corrupt nor lazy. (He decided to be polite and call them 'city servants' in his mind rather than 'town servants.') The killing fields outside the wall were empty of houses or hedges. However, at the same time, he thought of the city servants or the town rulers as old-fashioned. A vertical wall would fall down to a cannon attack, which had been described in the dictionary. He wondered whether the city's enemies lacked cannon. Were there such a lack, the wall would make a good defense. Cannons could shoot although not as far as on a lighter gravity world. He could not imagine any rebels lacking cannon, not even peasants. He puzzled over the weirdness and kept walking.

The city was not very high even though the building owners could make more money by building more stories. Partly, the result came from the high gravity; partly, it came from the locals intrinsic lowness; and partly, Djak thought, it was because they had not yet invented elevators, not any that were relatively cheap and safe. Elevators had not been mentioned in the dictionary. No one of any biological species would happily climb more than five stories all the time. Tourists would climb towers to look over the city and surrounding countryside, but they would only do it once; and soldiers could be ordered. In multi-storey buildings, local civilians sorted themselves by wealth, the poorer the higher.

'Well,' thought Djak, 'they don't have cheap steam; nor do they have electricity. It is not as if they lack forests — I don't know whether they have fossil fuels; I suspect they do, but either they have not discovered them or they don't need them. Their buildings are no more than two human stories high, but effectively in this high gravity, they are higher. Since locals are low, the buildings must have more than two stories even if I cannot see them.' He did not pay attention to windows, which showed multiple stories. 'In any case, the locals — I should call them hexapedes — have not invented cheap steam power, which makes cheap elevators possible.' He did not think about safety.

He would have grinned had he been able. 'Maybe they don't need to develop steam; they could go directly to electricity. Their initial power generation can be hydroelectric; they won't need to mine fossil fuels such as petroleum.' He was wrong about electricity. And he did not consider the convenient energy storage that had enabled mechanical transportation for a large number of humans. Compared to the energy density of modern batteries, that density of storage was primitive, but it was enough. That store consisted of refined, liquid fuels, which one powerful group had called gasoline and diesel.

Glatist led the flier into a paved courtyard, cobbles with flattened tops. “Please wait here,” he said. “I’ll get my boss.” Djak was willing. He stopped and lowered himself as if he were resting. Actually, he was checking for elements with nano-probes, but he did not say that. Pollution had settled and the courtyard suggested there were more metals in ores. Mostly, the pollution came from smelters and the like. The stones themselves had a little bit of everything, but the word was ‘little.’

Glatist took awhile. He was awake, but his boss was not. The sun had yet to rise. Djak wanted to gather energy from it. To escape the planet, a spaceship would have to push reaction mass through an electric arc and heat the results; chemicals would not do.

However, to collect the energy relatively quickly required more area than his back provided. It required a big photovoltaic sheet working in clear sunlight. Djak could build it; he not only knew how, he had the equipment and the energy. Moreover, he could build good batteries to hold the extra energy. They carried much more energy per unit of mass than chemicals. A spaceship could get off the planet with an electric battery that stored the energy. The electricity from the battery would create an arc that heated the reaction mass, which could be plain water. He would need a electromagnetic heater of some sort for his rocket engine, too. The oxygen in the water would not go fast enough at the kind of temperatures the solid parts of his engine could take.

He hoped to be given materials. They could come from ores he was sure the locals refined as well as from dirt. He could separate the elements and arrange them. At the same time, he could give warning that he was going to extrude a large black sheet.

Glatist’s superior officer, Nerrig, came finally. Djak wondered whether Nerrig’s deep breaths were the equivalent of human yawns. The sun had still not risen.

Nerrig tried to temporize. “Don’t leave yet,” he said. He meant ‘leave the courtyard.’ Djak thought he meant ‘leave the planet.’ Fortunately, the confusion did not matter.

“I won’t,” said Djak. “Please, bring me the ores for tin and copper. I don’t want to make a hole in this courtyard. I am going to extract a variety of metals from them, including more tin and copper than I need. You will receive the extra tin and copper, which you can sell. You will also receive the dross. I can separate other metals and gasses from it, too, and put the gasses into bottles. You know none of the gasses; you only know air. Also, you don’t know about most of the other metals. They will come as small bars. I suggest you give them and the gasses to the appropriate people. Once I have separated the relevant metals and gasses, you won’t have to throw away the remainder but can spread it on soil in which you grow plants that you eat. It’s not fertilizer, but it is not poisonous, either.” He assumed without thinking that the hexapede food was like human food plants; but that was neither here nor there.

Glatist's superior remembered the phrase about 'making a hole in the courtyard.' That was enough. He asked Djak, "How much ore?"

Djak said, "First, I am going to extrude a large black sheet that must be in direct sun during the day. It will be thin and somewhat flexible and will take up more area than I do. You will have to go around it. That you can do. It is a large courtyard. I plan to leave it in direct sunlight for a long time. The number of days will depend on the weather."

Glatist asked, "What is the black sheet for?"

"It is to collect 'energy' from the sun." For the word 'energy,' strange sounds came from Djak. Glatist was not surprised, since he expected strange sounds, but not his superior. "I am going to store that 'energy' in a 'battery'" — he made more strange sounds — "and once we have enough, build the ship."

Nerrig did not know of a ship; Glatist told him. "It's for his rescue and will be a living ship full of magic. As we can see, this creature is also a kind of ship, but evidently, it is not good enough." Djak, the creature being talked about, waited for a moment.

From the pollution he had figured out what the ores must be. And he thought more, then spoke. "I could build my ship at the same time I am collecting sunlight," he said to both Nerrig and Glatist. "I should. Please bring me more ore, about twice what we first agreed to." Nerrig had perceived and given into a threat. Djak understood that; he thought it more practical and polite to say 'agreed.'

"Also, I will take a part of the total as iron ore, rather than the ores for tin and copper; we need only a little iron so you will get most of it back. In addition, you can bring gold and silver ores. We don't need much of the gold and silver; we mainly need the other metals in the ore." — He wanted only a little gold and silver. The rest he would make into items that he would give to the hexapedes. He realized that if he did not take some gold and silver from what was visible, the creatures would not see that he took any since their ability to separate was not as good as his.

Djak went on, "Other elements are necessary. Fortunately, those ores have what I need. Each ore is different. I can get all the elements from dirt; it takes longer because the amounts are small. The different ores have more. I don't want to make holes to build the ship, not that such holes would be big after they have been mostly refilled by extras. The ship's crew is small. I am not as big as this 'flier.'" Neither Glatist nor Nerrig had thought that; they thought of Djak as being inside. Neither remembered that they had not referred to the ship as a flier previously although they had. Moreover, they had referred to Djak as a 'flier' farther away than what they erroneously thought of as his ability to hear. Djak had listened to them as they came out of Nerrig's quarters but he did not consciously remember that either.

"The rescue ship will be the same size as this 'flier,'" said Djak. "Because of the atmosphere and such, the ship cannot be as small as it might be. You don't know any of that. Just presume that the newly built ship will be about as high as the current body of this ship I'm in is long and as wide. Also, I will produce for you from the extras: pipes from the iron and nickel, plumb bobs from the lead, cutlery from the silver, rings and bracelets from the gold."

Nerrig did not want a hole in his courtyard and was growing more frightened at the being's size and presumptions. 'Maybe the flier can make a hole,' he thought. In addition, he was drawn to selling what he could. Even if the proceeds went to the army, he would benefit indirectly. "You will receive all the ore you need."

Meanwhile, Glatist himself was becoming less frightened. Partly, that was because he had off-loaded responsibility to his superior; partly, it was because he was in a familiar place. Partly, among his offerings, Djak had not listed any weapons. 'No doubt,' Glatist thought, 'he can destroy the city or a part of it. I am not sure how. Still, it looks as if he is trying to avoid that.' Glatist thought Djak's forbearance was a good signal of his intentions.

Also, he figured that flying towards an observatory was a good idea. 'As a general rule, an astronomer is smart,' Glatist thought. 'So this particular astronomer himself did not hear anything because he was grinding a large mirror.' — He did not know he was wrong. — 'Mirrors are a better idea than single lenses. Djinbit concentrates. Doubtless, he is absent-minded, too. The wait shows Djak's patience and understanding; mirrors rather than lenses show that Djinbit is intelligent.' Glatist did not question how long he thought Djak had waited nor his speech.

At the same time, Djak was puzzled by the city wall. It did not make sense. So he asked Glatist.

"It is a side effect of failing trees," said Glatist, "We are conservative. When the local crop fails, big countries, empires like Fortenst and Ildong, and our democracy, Glemria, can get the small amount of what is necessary for us from a distance." From the lack of a word that was not in the dictionary, Djak concluded that no hexapede had the notion of a vitamin. Glatist continued, "Failure happens when the trees stop producing, as they do at long intervals. I am speaking of the trees that are up close." He went on. "Our democracy provides free trade among its parts. No government, whether central or regional, is permitted to gain revenue from internal customs. When one region's trees fail, another region can and does provide. Free trade inside the country is not a cause of internal or civil war. The walls came from an external war.

"Empires tax heavily but make sure of supplies that their people can not make for themselves. Taxes push people away; supplies pull them together. In every empire we know about and in particular, the two close ones, taxes provide for both corruption and for a large army and

navy. The empires seldom have internal or civil wars: their big armies and their governments' supplies prevent that. They can and do have external wars. That is why the wall was built.

"Fortunately," said Glatist, "to get to us, both empires have to cross the ocean. To conquer us, the navy of either one needs to carry an army. The parts of the armies already on our borders don't have enough soldiers. Since the empires are afraid of each other — encouraging such fear is our diplomats main job — each thinks that only a minute portion of its army should be transported. Such a portion is big to us, but small to them. Although it is hard, we can defeat that army. Consequently, neither has attacked us since the walls were built.

"As I said, we are very conservative," said Glatist. "Our government is conservative. Everyone knows that vertical walls cannot defend against cannon. However, we have not had an enemy army come at us for a long time, although it has in the past. Besides, vertical walls give people in our army something to do." Djak thought that 'something for low ranking soldiers to do' might be most important for the commanders of a unit in what amounted to an irrelevant city. New sloping walls cost although they also gave 'something for low ranking soldiers to do.' If the country was fairly rich for its level of technology, the commanders and the even more powerful were not going to encourage the soldiers to do anything useful. Yet they would not want to spend extra money that might not be used, such as for sloping walls to absorb cannon fire. Also, however useless, vertical walls gave higher ranking soldiers a task as well.

Imagining trees' failure and seeing the clear area outside the walls also answered Djak's question about corruption; there wasn't any, or if there was, there was little. He did not have to speak or hint. Evidently, in the democracy, Glemria, the creatures in power did not want their agents to be corrupt. Both species, human and hexapede, considered the powerful to be 'principals' (in the two languages, the different words came from 'first'). Djak applied theory concerning corruption to his observations. In particular, Djak supposed, principals did not want the officers of their army to be corrupt. Then the agents might be unwilling to defend them strongly.

In any case, if corrupt, Glemrian army officers could themselves gain too much wealth and power. The Glemrian powerful were far from the time when all leaders were military. Perhaps that was why principals had pushed anti-corruption efforts. They felt that leaders should lead, not fight as common soldiers, as past leaders had. That was too dangerous. Nonetheless, they wanted their armies to win. Consequently, principals had selected their agents for honesty and capability rather than for their relations to the powerful. That meant that principals could not guarantee good places for their children. Their large numbers of children meant they would mostly have to become agents anyhow, not principals. From the powerfuls' point of view, failing to guarantee principal places was a downside.

Fortunately, all this had occurred generations ago. Djak did not know but he extrapolated from the conventional mechanisms that prevented human corruption: the powerful had changed rewards and penalties from what they had been earlier. They had widened the information they gathered, both from agencies inside the government and from those outside it. They had spoken against corruption. Even though cultural expectations took a long time to modify, he presumed that speaking finally had had an effect.

Djak expected that the powerful had removed the possibility for their agents to have the 'monopoly plus discretion plus little accountability' that leads to corruption.

Chapter 4

Those in power who knew of Djak wanted the big creature to look for enemies. They did not make clear who those enemies were. At first, they spoke only of defense.

The powerful in the capital, which was informed of the creature flying over and then of Glatist 'capturing' Djak, first considered him a big bird. That fit their legends. They were only a little surprised that the 'bird' could talk. Initially, they did not think of Djak as having a more advanced technology. For them, the first messages about Djak were the most important even if limited. It never occurred to the powerful that the 'human-based computer,' as Djak called himself, was continuing his mission on the ground in a fashion believable to the local sapients.

Those in the capital thought of the bird as being ridden, the rider engaging himself in reconnaissance. The bird and rider could defend themselves by staying high over the enemy. The army could worry about other birds later. Although the hexapedes had a longer time-horizon than humans, they still thought in terms of a primitive agricultural culture: From the point of view of the leaders, the benefits and losses of war summed to zero; war was a success when they were victorious. Good reconnaissance, 'seeing over the hill,' helped ensure that others lost.

Djak could, of course, simply fail to carry a rider. He could refuse to fly. He could not fly at the moment anyhow (or rather, he could only make a short hop), since he was (mostly) a downed glider but he had not explained and the hexapedes did not know.

Regardless, he was in the process of making the photovoltaic sheet. He could collect the solar energy on his own back, but a big sheet was much quicker; rather than spend a very long time, a big sheet would require merely a long time, presuming the daylight was sunny. Even with clouds, he could collect a fair amount of energy. Moreover, he did not want to work without the hexapedes. Besides finding out about them, he wanted to persuade. He figured that persuading their powerful was a good beginning.

After Nerrig gave him ores, he began to separate the elements he needed. He made a battery; except for the extrusion, neither the battery nor anything else could be seen as yet. Then, shortly after extruding his solar energy collector, he began converting what he considered 'excess' from the ores. He produced bars of strange metals and bottles of strange gasses to be given to alchemists on the condition that they make widely known what they discovered. In addition, he made pipes, plumb bobs, and cutlery to be sold, as well as rings and bracelets, which he originally thought would be sold, but were sent to the capital instead. The rings and bracelets were made from gold.

When they came, the rings and bracelets convinced the powers in the capital that Nerrig had more than a bird. For one, the rings and

bracelets were better made than any seen before and gold was an easy substance to shape. The goldsmiths were good, but as one of them said, "We cannot produce as smooth a surface as this creature."

The powerful changed their opinion about Djak. They read the later reports. Perhaps, they thought, the flying creature really was in need of rescue. If that were the case, they thought he should be weak. They were wrong about his weakness and his need for rescue. However, that was neither here nor there. Even though they had seen gold rings and bracelets, they had no sense of his advanced technology.

Meanwhile, Djak spoke to Nerrig. "I am happy to make pipes, plumb bobs, and cutlery for you to sell from the excess of what I need. I am happy that you give other elements to your powerful in the capital and to the alchemists. I doubt the alchemists will understand the elements you give them, but they can list properties. That is a beginning."

He did not speak of Djinbit, although Djak knew Djinbit wanted knowledge as well as tools. Djak pretended he did not know of Djinbit. That fit Nerrig and Glatist's understanding: Glatist reported that Djinbit had been grinding another mirror, a bigger one compared to the one he already possessed, had not looked out, and had heard neither Djak's landing nor his conversation. That was wrong, yet also neither here nor there.

Chapter 5

After Djak and the soldiers left the observatory, Djil and the flat sheet stopped their disguise as a table, the flat sheet first. It carried the mirror to the regular table. The mirror was silvered, completely ground, and big. Then Djil went back to being herself. All looked the same except that Djil was a little smaller.

Djinbit realized that his technology was far behind that of the strangers. He still did not know about 'electricity' and other strange notions although he was beginning to be able to remember and pronounce the words.

"We will make eyepieces, a tube, and mount for this mirror," said Djil. "It will take awhile, unless you have metals to give us. Otherwise, we will have to take them from your entrance way and from soils, and since we don't want to give away that we are here, we can't take much from any one place." She did not say anything about how they built the table or why they did not want to give away their existence. Djinbit was puzzled. Besides, how was he to become known? He decided to wait.

"Do you need metals?" he asked instead.

"Yes, or 'oxides,'" said Djil, looking like a six-footed child, as she had before. As far as Djinbit was concerned, he still did not know the meaning of the last sound, 'oxides.' However, he understood 'yes;' that was in his own language.

"I can give you metals in existing mounts; I can give you their single lens telescopes, too. Will they do?"

"Yes," said Djil. "Let me have one, first."

Djinbit went up to the top floor, chose his worst telescope, brought it down, and gave it to Djil.

She promptly did something; Djinbit was not quite sure what. First, Djil absorbed the old rods that held up the telescope and extruded three that were new. They looked different. "These are stronger," Djil said.

Then she made a big change to the part of the mount that grasped the telescope tube. That took a little longer. "I'll need a weight; I don't have enough metal for it. It can be just about anything; all it has to do is be appropriately heavy," Djil said.

"Will a rock do?"

"Yes," said Djil. "It should be about so big." She showed the size with all six of her arms — the top, the bottom, the left end, the right end, the near side, and the far side. "Metal is denser, but rock will do. It will ride up and down this rod in a metal container although you don't need that. The weight should only move once. Presuming that, only the setscrews need metal. On the other side," both Djinbit and Djil had three hands on each side, so she could not say 'on the one hand, on the other hand,' "if the counterweight were all rock and broken, the mount

would be broken. You might drop it. A metal container is less likely to break and if the rocks inside are broken, the rocks won't fall out. And even if they do, you can put them or gravel back in and rebalance. You can continue to use the telescope when I am gone."

Djinbit had not previously thought of Djil leaving. 'How much knowledge,' thought Djinbit, 'can we obtain from these visitors?'

Djil was almost reading his mind. "Don't worry," she said. "We will not leave soon. You won't be forgot. I don't know how yet, but we will publicize you. Also, you hexapedes are interesting. We will help; we will teach you about electricity and elements. Your alchemists who keep secrets will have to become chemists who make their discoveries public. You already are developing the precursors to an industrial revolution; we will merely give you advice and try to prevent Earthly mistakes. We will teach your mathematicians a little about probability — you already know a great deal — and direct them towards the history of life. We will aim biologists towards probability and history."

The statement about being remembered relieved Djinbit, so he asked, "What do you mean, 'aim biologists towards probability and history?'"

"We have found," said Djil, "that some information about species sticks around for generations. It derives from birth. Some is relatively new and depends on the current environment, by 'current', I mean goes back a few generations, well, more than a few, but not that many. For thinking creatures beyond their origins, that means culture in the broadest sense. Some is a mixture, but that is more advanced. As a result of changes derived from birth, 'genes' change. The best carry on." The word 'genes' was not in Djinbit's language but the rest was. "When I say the phrase 'derived from birth,' I mean derived from the internal environment of a living body, the external environment of other biological beings both of the same species and of other species, as well as the non-biological environment. Those kinds of changes require generations.

"Culture is important for a society that makes changes in less than a generation.

"For example, you are innovating the precursors to an industrial revolution. That is good."

"What do you mean an 'industrial revolution?'" asked Djinbit.

"By 'industry,'" Djil answered, "I mean, 'producing material items more cheaply.' In the past, manufacturing came first; in our language, the one word, manufacturing, derives from the two for 'hand making.' In factories, workers were taught to do only a small part of the whole, but do that well and quickly. That meant you had to have a number of workers and the items had to be more or less the same. Later came machinery that could make items. Usually, each machine or set of machines could make only one item, unlike a skilled person. The word 'manufacturing' changed to mean 'machine made.'" She paused for a moment and then said dryly, "Few noticed.

"Machinery could make an item faster than a person or group and often much more cheaply. That is why we call the change a 'revolution.' Also, at about that time, seeking became both more routine and more funded. Eventually, innovation resulted from seeking.

"Unfortunately, or maybe fortunately for those at the other end," Djil continued, "you don't have much trade with civilizations that are dramatically weaker than you. That means people ruled by old fashioned feudalists are not robbed except by their own people. It also means that your society has fewer of the big, long distance traders who made up the beginnings of the bourgeoisie on Earth. At the same time, you in Glemria have fewer hindrances than the empires, although you have some. Peace is important, too. You have that here in your democracy.

"For you personally," said Djil, "I will make maps of other planets. Incidently, Earth has two inner planets; you have only one."

Djinbit was warmed by the promise of maps. He knew he was smart, but the interstellar travelers had had more time to investigate and more time to develop powerful instruments.

Djil continued. "Hmm . . ." She actually made a noise as if she were spending as long a time in her thinking as humans or hexapedes. "Perhaps we will not have you pretend, but will say that the maps come from us, but go through you. I will have to talk with Djak.

"I will tell you about meteor hits so you don't think every circular feature is a volcano. That will keep you from searching in the wrong directions, like humans did."

"I know about meteors," said Djinbit. "Good," said Djil, "but do you know what happens when they come very fast and strike in a vacuum? When you don't have rain, surfaces result from a mixture of volcanos and meteors. And from other influences, too, but you need not concern yourself about them, not in your lifetime. I guess Djak or I will have to speak from authority since I don't see how you can produce proof at this level of technology. You know about speed and you know about meteorites. Do you know about the vaporization of rocks?"

"No," said Djinbit. "That makes sense," said Djil. "You can't make rocks hot enough to vaporize with fire. You need concentrating solar mirrors. Although you have mirrors, you have not thought of concentrating solar energy yet. We'll have to speak from authority.

"Fortunately, you hexapedes already know how to seek; moreover, you as a people know how to fund seekers and their research. Even governments give you a little money. You as individuals are not dependent entirely on your own wealth or on one or a few private patrons. Nonetheless, you as a group will have to increase funding. You have conservatives in power. They will look ahead and see that eventually science leads to technology. If only to protect themselves and their children, they will support your funding. At least, I hope so.

"Feudalists and other backward types will come into power occasionally, most often in authoritarian states. They will even come to power in democracies. Their excuses will sound convincing. Very likely, they will believe themselves, at least their more general statements. You will have to suffer through such droughts.

"Conservatives who are not feudalist will pay for technological development; others will pay for it, too. Development is much more expensive than any seeking.

"In any case, within a few of your lifetimes, you will surpass us and discover what we have not." Djil grinned; unlike Djak, she was in a body that permitted grinning, although she did not grin like a human.

"You already have mathematics," said Djil. "That is required for any kind of advance beyond the beginnings. The mathematics of probability is required for anything involving life. Remember that organisms vary. You have to think differently than you do with physics. You have to think in terms of a population with an average but many different; it's not like thinking of electrons which are all identical." (Djil forgot that Djinbit did not know of electrons.) "Descendants are selected from among those which live and are fertile. Most animals and plants here and everywhere else do not transmit information by language or imitation, but through the biology of birth. That information is passed on forward only by those who survive and reproduce, a probabilistic action. It is what we mean when we talk of 'genes.' The process is very slow. Well, 'genes' carry the information physically; the mechanism uses that information.

"Creatures like us change more quickly. We speak. Imitators change quickly, too. Changes are called 'learning.' They can be good or bad; I am not claiming one or the other, only that in our sort of creature, changes come in less than a generation."

She stopped for a moment, then went on, "I suppose probability is necessary to understand what happens with speakers and imitators, too, and with the organizations devised by them or their children or grandchildren.

"In the centuries when probability was first applied to life, only a few humans understood the mathematics. It is still the case for most of those who are not seekers. Indeed, it is still the case for some seekers. In the past, most seekers depended on their cultural understanding; that especially applied to biologists. In any case, long ago among humans in one of our regions, certainty had became a philosophical dogma, perhaps to compensate for the uncertainty of everyday life. Only later did those humans, at least some of them, come to accept uncertainty, which is what probability is about."

Djinbit was not sure exactly what Djil meant, but was willing to listen. At least, she spoke of 'life-studiers' and the like. Djil carried on. "Perhaps our delay in understanding uncertainty was because so many things of our size are either there or not there; they have a probability

of one or zero." Djinbit moved up and down. He understood. "Such items fit the first fundamental law of mathematics," said Djil. "There are four of them. The first is the determination of equality. If an item does not exist, it is equal to nothing. If it exists, it is equal to itself or something else like it.

"Humans not only apply the notion to non-human items, but to themselves. Many people like equality as a temperament since it leads to sharing. Adults you know and trust should be equal to you. That is why you have sharing. I suspect your people are the same as humans since the formal mathematics is the same throughout the universe, like physical laws, not social laws.

"In addition, I suspect that people prefer one of the bases of formal mathematics even when they understand the rest. That has not been proven, although other studies suggest it. Based on different studies, a portion of the human population, perhaps a third or a quarter, prefer equality. It leads to old-fashioned logic as well as sharing and naming."

"How does a liking for equality support naming?"

"There are many different existing items," said Djil. "There are different numbers and different objects. Either they exist, in which case they are named and equal to themselves or to other things more or less like them, or they don't exist, in which case they are nothing and equal to nothing, yet still named. However, for probability, you need the mathematics of ratios, which you prefer."

"I don't know much probability."

"No," said Djil. "You personally don't, not that it matters. Based on the dictionary, you as a species don't have a huge number of mathematical tools although you have quite a few. From your level of technology — I am inferring your level of technology and culture from your dictionary — humans took more than two gross years to gain the tools you already have. As far as mathematics is concerned, you, taken together as all of you, are ahead of humans when they were at the same level of technology. You have had calculus for some time! You need to do what you are doing, which is physically to see more."

Djinbit was pleased that the creature said he was doing right. He was not sure how much additional mathematics he could learn and wanted proper mathematicians to learn the tools. He did not worry, as Djil did, about cultural change, whether it was necessary first to have traditional logic and its accompanying certainties before later talk about the probabilities of existence or non-existence.

On a separate subject, Djil said, "Our eyepieces are going to be made with more than one type of glass, each with a differing refractive index. We won't mix the glass or do anything like that; you will be able to manufacture them." Djinbit moved up and down. He himself did not know how to combine individual lenses, yet he could see how that would work.

"Simple astronomical eyepieces," Djil continued, "have two separated lenses; each lens has two elements, each with a differing refractive index. We are going to make you Kellner type three or Plossl. Both Kellner type three and Plossl are names for the same type of eyepiece with separated lenses. They have a wider field of view than your single lens eyepieces, although not as wide as eyepieces made with an advanced technology. You can reproduce the ones we will provide you. We will show craftspeople how to make them, so more people than you personally will know. The eyepieces will have the same diameter yet come in different focal lengths. The similar diameter means they will fit into a single focuser. The difference in focal lengths means they will have different powers when mated with a constant focal-length main mirror.

"Your first mirror will have a focal ratio of eighteen. It will be the one you partly ground." Djinbit knew he had hardly ground it at all. "It is very shallow and has a circular cross-section. The light will bounce off a flat mirror that is not in the way of the big mirror and go to an eyepiece. You will want primarily to look at planets with that one. It will be long. We will make finder 'scopes, too. They won't be as big as your main telescopes. Generally, they will have a smaller magnification. They will be attached to and look in the same directions as the bigger telescopes. Their sole purpose is to make it easier to find astronomical sights.

"After we make the tube, mount, and eyepieces for your first big telescope, we will make the other; neither will be big like ours but they will be big to you. Your second telescope from us will have a shorter focal ratio and a parabolic shape, which collects parallel rays like those from stars and planets. (With a large focal ratio, like that of your first mirror, the difference between a circular cross-section and a parabolic cross-section is too small to matter.) We will show you how to test more conveniently. Then you can make more. Testing will tell you how you are doing.

"The telescope with the parabolic main mirror will have a small, flat, diagonal mirror that will block some of the light going to the big mirror. The small mirror will cover a part of the big mirror, but not much. We call the design a 'Newtonian.'" She made a strange sound that Djinbit now recognized as a word in a foreign language. Djil went on speaking. "Unlike the other kind of telescope, you will have to climb on portable steps to see into its eyepiece. It is toward the front of the tube. We will also build you another equatorial mount.

"With patience, you can build all the lenses, mirrors, mounts, and eyepieces. With genius, you could invent the one that is not in your books. This is the mount. (Well," she said parenthetically, "you could innovate eyepieces, but that is not invention. I suppose having two elements rather than one is invention, but that is rather obvious.) Mirrors have been discussed, although you are the first to have built a mirrored telescope. Among humans, the first telescopes were invented when lenses became good enough, which was centuries after the first

eyeglasses. Human eyes can handle inferior lenses in eyeglasses. You don't need eyeglasses. Among humans, telescopes came later although you hexapedes have had them for a long time.

"Among humans, the first mirrored telescopes were invented later than telescopes with lenses. In that sense, humans were just like you hexapedes. However, humans used mirrors that reflected less and which consisted of a mix of metals.

"If we do have you pretend, though I don't think we will, the assumption is going to be that you are a genius to think up the mount, which we call equatorial and tracks the stars. If you don't, you will be our conduit for astronomy. In both cases, you are a genius for devising a practical reflector.

"Even with your level of technology, you can make the optical parts exactly. You have the patience to grind and test. Making more telescopes will take time. Others will follow." She paused for a moment. "Yes," she continued, "we will have to teach craftspeople how to make stronger mounts, how to make mirrors more accurately, and so on."

Meanwhile, Djil and Djak decided it was not necessary sociologically for traditional logic to come first and the mathematics be inadequate. The hexapedes had discovered more mathematics than humans at the same level of technology. A few of them understood enough probability to understand evolution. They had only to be pushed to study the history of life.

Unfortunately, pushing was not easy with mathematicians. They went off on their own. Djil kept remembering the human managerial phrase, 'herding cats.' However, it was clear that the history of life was important. And even the most life-hating of mathematicians would like the new mathematical tools.

Mathematicians had to understand that most biological entities wanted to keep reproducing regardless of the bigger environment. Only sapient creatures like humans and hexapedes could see a large enough population and far enough ahead that they made use of social mechanisms such as dislike or taxes to regulate their overall numbers.

Djil said to Djinbit, "When the population is seen to be excessive, assuming people want a smaller number, the population should decrease. Families with too many children should be disliked. An example that led to an increase in population: a sudden drop in mortality rates among humans was pushed by a drop in child mortality. That had happened in less than a lifetime and meant an increase in population. In the advanced countries, families had fewer children. That would reduce the population eventually assuming no immigration. Perhaps they did not respond to population directly; nonetheless, richer families had fewer children. Taxes would (eventually) punish those with large families. And when the population is seen to be small, the population should increase. Families with many children should be liked; taxes should reward them.

"With poor thinking, when cause is not separated from consequence — lesser animals do not separate the two — planets have sapients with beliefs that do not match their world. It happens that some humans do not separate cause from consequence. When there are too many, humans either die before their time or change their beliefs. The same happens with non-speaking animals, like rabbits, but humans do not consider them as much as people who can speak and state their own beliefs. I do not know about hexapedes."

Djil went on to say, "Among humans, barbarian tribes lacked the technology to kill more than a portion of their enemies. To be militarily successful, tribes had to grow their population to outnumber their rivals and to win military victories. That generated conflict between population size and military success. With primitive technologies, for military success, the population had to be large, even though most people preferred it small. The desire for a large population was also the argument for being 'fruitful and multiply.' Peoples with more modern technologies had the same problem. They had 'conscript armies.' Only peoples with the most advanced technologies and an exportable belief system could get away with having a smaller army. The hexapedes are not going to develop that for some time. Fortunately, Djil thought, barbarians lack the technology to hurt much of their planet although they had fire.

"In any case, the mathematics of probability cannot be strange to you. More than a few ratio-lovers will enjoy them. Unlike humans, they would know not to presume that everything comes down equally on either side of the mean or what most humans call the 'average;' sometimes there are long tails on one side or another." In addition, Djil hoped the meme of uncertainty would travel. It did among humans in 19th century Britain. They purchased insurance even though few understood the mathematics.

Chapter 6

After receiving more ore, Djak said to Glatist, "Please find me books, fairly recent ones. I want to gain a better sense of your technology. Please give me both fiction and non-fiction. I especially want fiction. Besides showing dreams, fiction shows the technology that is common among writers. Speculative fiction shows wishes or expectations rather than realities. Or it shows abstracts. I also want non-fiction. That should show what is possible." He did not say anything about learning more vocabulary although that was also his intention. Glatist did not think to ask how Djak had learned to speak.

Instead, Glatist asked whether he would get the books back. "Yes," said Djak. "Please bring me a great number." Glatist decided to borrow books from his library. It was not public but did loan to him. He paid part of the costs of the librarian and books, unlike the very rich who paid for all the costs of their libraries. The social and legal organization had been invented a generation or so before. Not knowing that Glatist was thinking about his library, Djak continued speaking, "I will look at each page quickly." He would also copy and view them quickly although he could not consider them as quickly but he did not say anything about that.

Glatist understood that Djak would copy the books. Glatist did not care about the copying; it was part of an 'advanced technology.' Besides, they were from a library, which was to say, the books were all bought even if new books were still in copyright and their copying was restricted by the government. He failed to think of private ownership as protected from bigger thugs than his. Even though he was in the army, he did not consider his government or its judicial system and its army and navy as defending him locally. He thought of himself as defending the country against foreign empires, which also protected property, both real estates and copyrights.

Glatist thought of copyright as different from property he could point at. It had only come into being after printing was invented and no more than a lifetime or two before him. In any event, he decided that if Djak could make a ship, he could copy books. He was right. Glatist figured the means was magic. He did not know that Djak not only could remember the text but also could record the molecules that made up each book. That kind of recording destroyed the original but Glatist would get a copy back that was identical to the atoms. He could not see any difference and Djak did not tell him. Djak kept his copy compressed so it took up less volume than a bacterium. Djak could read it. Only when someone such as Glatist needed a copy would Djak reproduce the book as a large object that a person could read with natural eyes.

Meanwhile, Djak gathered energy from the sun, separated elements from the ores he was given, and produced both a spaceship that could travel into orbit from the surface of the planet and various items he gave to Nerrig to sell or to send to the capital.

Djak did not need the spaceship — he radioed himself as a backup each day or more frequently if needed — but the spaceship was the visible means of his rescue and made sense to those with such a low technology that they did not know about radio. In any case, other than Djinbit, the hexapedes did not think he could transmit far enough, even if it was 'magical communication at a distance.' He once needed energy. Now he had enough energy and enough elements to build anything the size of his spaceship or smaller. Of course, if he built anything large, he could hollow out his spaceship, both to hide his construction and to provide atoms. 'Fortunately,' he thought, 'I was not planning to build anything so big.'

Both Djak and Djil were curious about the hexapedes. They planned to stay longer than they would if the planet were settled by humans. Meanwhile, the two would teach economic development. If they were smart, the hexapedes would make fewer mistakes than the humans; in short, they would experience less pollution and fewer subsidies. At the same time, teaching would give the two an excuse to ask questions.

Chapter 7

After the time it took for the information to cross the ocean both ways, leaders in the capital of Glemria learned from a spy that the empire of Ildong had obtained information from its spies that Djak was more than a big bird, although no one knew what he was. Moreover, the democracy's spy said the empire's government was planning to publicize Djak prior to a request that he be put under international control.

The spy also said that the empire of Ildong said that if the flying creature were not put under international control, which no one expected, the Ildong empire would attack. How was another question, as was the size of such an attack.

Djak learned from people in power in Glemria. He, of course, passed the information on to Djil. Not knowing of her, they asked him to keep quiet. Publicity would make Ildong's army and navy more dangerous. Unusually, they would have reason to fight Glemria: a talking 'bird' under one country's control. Publicity would also inform the other empire. That, too, was dangerous except that Ildong's emperor had thought, 'Perhaps, our two empires can join against the democracy.' They could fight each other later.

Djinbit learned from Djil. He was not going to tell anyone. She said, "I don't want to be bothered. Also, I don't want to waste the sheet's time." Djinbit finally understood why Djil and the sheet disguised themselves and hid. Djil also said, "Djak won't join any army or navy but he will spend time preventing war."

"How is he going to prevent war?" asked Djinbit.

"First, through discussion, both with your people and with representatives from the empire of Ildong. We don't expect good words from the empire, but might. Second, if need be, we will damage the empire's troop carrying ships. We could hurt the troops on land, too. We may have to do that although I hope not.

"The empire will not be able to send an army to Glemria. You don't have to worry about the troops on your border. There are not enough of them. As for the ships: our bombs will be small and smart. We call them torpedoes. They will be delivered from the air and then go underwater. We are able to send fliers across the ocean."

Initially, Djak could not fly (except a short distance) even if he wanted to, although he could always make smaller creatures that could fly long distances. By the time the spy reported to the leaders of Glemria, Djak and Djil's ship had the energy to take off vertically, extrude wings, and fly anywhere.

Djil continued, "After release, the torpedoes go underwater. They don't kill any sailors unless there is a massive amount of error. Indeed, unless the sailors or their managers are very incompetent, which is possible but not likely, no ships sink. They are merely damaged.

"I don't know whether we will have to prevent the Ildong empire from sending an army again against you in Glemria after it has built new and repaired the old ships or whether we will merely scare the emperor and his navy. Probably we will do the latter. That is more elegant than damaging sailing ships and frightening everyone.

"Indeed," said Djil, "we should frighten the emperor first. Maybe we will have a flier land on the emperor's lawn when he is going by and say, 'I could have been a bomb.' The flier could be the size of a regular bird. It would not have to be as big as our vehicle; it just has to be visible and big enough to look dangerous. I don't know what we will end up doing. In any case, we have the capability. What we do depends on the emperor's response and how well we learn the language."

"I have a dictionary and grammar for Ildong," said Djinbit. "The grammar is for us, so it is written in our language. It has a short vocabulary list. The dictionary is in Ildong's language. Ildong uses much the same alphabet as we do."

Djil nodded, which is to say, she moved up and down, and said, "Very likely, it comes from the same written-language ancestor."

Djinbit went on. "Ildong's language is more phonetic. I am not sure you will have the pronunciation right, however."

"Please give me the dictionary and grammar. I will be able to send Djak the information by 'radio.'" Again, the last word was in Djil's language, but Djinbit knew that it meant 'magical communication at a distance.' "As for pronunciation," said Djil, "we have the capability of listening to people in the Ildong embassy as they speak their own language. We can install that capability almost immediately. I don't know why Djak has not done that already. Probably he has not thought of it. In any case, the sound of Ildong, its music so to speak, will be the basis for talking to the emperor. Most likely, the emperor will be familiar with the accent that is prevalent in his embassies.

"Also, it is probably a good idea to have someone tell us and pronounce the Ildong alphabet. That person need not have the same accent, but he or she should be comprehensible. That way, we can understand the dictionary without trouble."

"I can pronounce and show you the alphabet," said Djinbit. "I can be understood in that language. Sad to say, my accent is terrible."

"Thank you," said Djil. "Your accent is irrelevant. As for information from the Ildong embassy: no, Djak will not provide it to your government, even though your democracy is better than their empire. Our recordings depend on advanced technologies beyond electricity. You would not understand or be able to maintain the 'bugs;' that is what we call them . . . They can fly and are as small as your insects. Moreover, they can leave small, disguised recording devices. It is doubtful anyone will notice and, certainly, no one will understand."

"Few insects come into the better parts of town where the Ildong embassy is located. The sewers are covered."

"That is useful to know. Our bugs will come in the evening and enter secretly. They will be disguised to look like your normal, non-inorganic, biological bugs. Don't worry. Unfortunately, we humans have plenty of experience both using our kind of bug and countering them.

"We should also put surveillance devices in the Fortenst embassy. Maybe we should scare its leaders, too. Do you also have a dictionary and grammar for the Fortenst language?" Djinbit moved up and down.

Djil paused for a moment and then spoke more. "Djinbit," he said, "I just talked with Djak. You will not have to lie. We will tell people about the mount and about the planetary maps. We will teach your craftspeople. I don't think you are a very good liar. On the other side, you will be the person with our astronomical knowledge, so people will have to come to you. Or at least, they will have to be taught by you. I don't know exactly what we will do.

"We still haven't publicized you. Please do not do anything public right now. It will probably be Djak who comes and advertises you. By then, he will be known widely. From the point of view of the rest of you hexapedes, his intention was to come to your observatory originally but he was redirected to the city. I will stay secret."

Djinbit accepted that. He knew he was bad at pretending. Djil was right. He almost regretted he would not be proclaimed a genius for more than a successful, mirrored telescope. He did not quite regret; he was fundamentally honest. Moreover, he would be the conduit for astronomical knowledge.

'Wait a moment.' Djinbit thought to himself. "Djil," he asked, "why did you use the word 'we' just now?"

"Djak and I are separate beings. We have been that way since before we left Earth. I suspect the mission planners felt each of us needed someone to talk to. They picked us based on our names and an old rhyme. We supposedly went 'up a hill.' I did not disclose Djak to you immediately .

"The 'flat sheet,' as you call it, is a 'robot' that I made." Without thinking, she used a human word for 'robot' but it obviously meant 'golem' and continued speaking. "The robot sees, hears, and feels, has access to our memories, can speak, yet is not conscious. I did not want to make another sapient. If the robot were conscious, he could fit in our interstellar spaceship; not many can and be what you consider alive."

"What do you mean," asked Djinbit, "when you say what I 'consider alive?' "

"We readily make copies of ourselves that can be used as backups. They include all our memories. They need not take up much space. They are so small, a human cannot see them. Based on the nature of your eyes, you can't either. Such a copy or backup does nothing. To become alive, to be built, requires a robot, either sapient or non-sapient. Copies that do nothing are a good way to travel between stars. They are what you call 'dead.' Otherwise such travel can be very boring

for sapients. We don't design and build non-sapient robots to become bored.

"Djak and I stayed alive the whole time because we could. Alive, we are much bigger, although not as big as this construction, my body. We slowed down enormously. That is why we would look to you as if we were sleeping. We were not; however, we processed external information much more slowly than you, even when you are asleep. We processed internal information equally slowly. To you, we would seem to be sleeping or, perhaps, we were so slowed down we would seem to be dead. I don't know how fast we have to be for you to think we are sleeping rather than dead. We were very slowed down. I remember seeing stars move. A non-sapient robot lived at the normal rate the whole time; he would have speeded us up had it been necessary. We were so slowed down that if we had sped up ourselves, we would have taken too long. Fortunately, no robot had to speed us up. We did not have our accident until the spaceship had slowed down and we had already speeded up."

"How did you have your accident?" asked Djinbit.

"We collided with a grain of dust going very nearly the speed we were. If it or we had been going faster, it would have vaporized itself and an equal amount of us, but it was going slowly so it penetrated. 'Slow,' of course, is relative; it would be fast for you. It was very bad luck. We were ready for speeding objects. Moreover, our radar was down for its post-flight maintenance; if it had been up we would have dodged. You don't know what radar is, do you? When it works, it is way of detecting things.

"Oh well," Djil said, "the damage has been fixed and it probably won't happen again. We told Earth as soon as we built a radio transceiver that could send radio waves the distance and they will likely send the information to others so they receive it when they are where they can build radio transceivers, which means in orbit around stars. After the news arrives at Earth, new probes will hear it immediately. It is a really stupid error; probably someone thought that the chance of an accident happening that way is so low that it could be disregarded. We are recommending that maintenance be scheduled later, to come after real or potential problems when we are in a regular orbit. Then the chance of an accident is very low!

"From your point of view," said Djil, carrying on, "it's magic that we came here and are suggesting ways to improve yourselves materially. Even with your mathematics, it will take several of your lifetimes for your knowledge and technology to catch up. We can point you in the right direction, both you personally and others. We can direct you away from wasted effort, but the major changes have to be cultural and encompass just about everyone.

"Meanwhile, I have just been told by Djak that we need to discover from how far away you can see my finger with your naked eye. My finger will be the base of a very long and thin triangle. We are really

trying to find out the angle of a dark object that you can resolve against the sky. You hexapedes are different from humans so we don't know for sure, although we can guess. I know you vary among themselves, so as a single source of information you as an individual will not be the best. However, we are going to set out relays for communication, disguised, that cover less than third the same angle at a distance from some one on the ground. We need that information. The relays will look like birds in the sky. They will be above your weapons' ranges. Except for astronomers who might notice through a telescope, I doubt anyone will see them."

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Besides dealing with its Emperor, Djak also had to deal with the man who became the prime minister of the Empire of Ildong. He had persuaded the most important of the army and the overt and secret police that he could run the country better than the Emperor. Kelding was ruthless. After Djak published his book on implications, which he had not done at the time he acted to scare, Kelding learned about humans and decided that hexapedes were similar. To keep his power, he expected that the local powerful who supported him would become experts at imprisoning and killing rather than industry, since they would have to imprison or kill any who asked questions or who innovated. The police and the army were already such experts.

Although Kelding was unable to think up new social technologies besides the one that gave him power, he wanted to avoid dangers. To become prime minister, he had called for industries to be the basis for representation, as if no new industry would ever be invented in the future and no hexapedes would innovate. He had specified the representation of existing large unions that went along with him. He also had proclaimed medical care for those in cities as well as pensions. His followers were the army, the police, and many people.

At the same time, Kelding had persuaded the Emperor to become a 'constitutional monarch' but keep his income. The Emperor and his followers liked that. The man looked like an emperor; however, he wasn't much of a ruler and his followers enjoyed his and their debaucheries. In human terms, the prime minister was a fascist: popular with many, hated by some, more adapted than any before him, and without a governmental process for continuous adaptation.

Chapter 8

Ildong's emperor was walking in his flower garden when one of Djak's small fliers landed on the walkway in front of him. (Later, he claimed his Empress was with him, but she wasn't.) The flier took very little distance to land. It said, "I waited until you went for a walk — I can wait for a long time. I was produced by what you think of as the big 'bird' in Glemria. The big flier has an advanced technology. I am a small flier. Don't attack Glemria. Another small flier is going to your enemies in Fortenst. I could have been a bomb." It then took off and acted as a relay and power supply for the surveillance 'bugs' it delivered at the same time. Neither the relay nor the surveillance devices were seen.

The emperor jerked. He was surprised. So was everyone else. In particular, the head of his guards was surprised. He had been accompanying the emperor, which was unusual for him. This time he walked in the garden, too. He had just been thinking that the emperor was very safe. No one had expected the small flier, the words, or their claims. Djak had forgotten to scare the Prime Minister.

The voice, the emperor noted, had no hearable accent and sounded just like any courtier. 'No hearable accent' meant the accent was similar to his and his courtiers' accent. 'How had the flier acquired it?' he asked himself. Djak was more powerful than expected.

"You are not responsible," the emperor of Ildong said to the head of his guards. "We did not foresee this." The emperor spoke with a 'royal we' at the same time he used a 'regular we.' No hexapede had imagined what Djak could do.

Another vehicle also flew across the ocean. It went to Fortenst and waited until the emperor and empress walked outside. That did not take long. It landed in front of them and delivered the same message. It took off immediately and climbed beyond visual range. There, as with the flier in Ildong, instead of the low flying bird it had previously pretended to be, it disguised himself as a fairly common, high flying bird. There was a slight chance someone saw it transform. That 'someone' would have had to see it through a telescope, most likely an astronomer. It swerved and swooped to avoid that chance, which was not likely. Indeed, the chance was very improbable since it took place during the day. Regardless, it would learn through the bugs, the sensors, if it was seen and if the reporter was believed.

According to the sensors, nobody saw the transformation. The presumption was that the 'bird' had flown away. The emperor and empress had hurried inside; they had wanted to be under a roof. However, several sensors in different places in the same room, placed by inorganic rather than organic 'bugs,' heard the Empress say to the Emperor, "Let's not do anything for the moment. We do not have to. Regardless, doing nothing is safer. Our spies can find out whether the Emperor

or Prime Minister of Ildong received a similar message. Then we can decide." The Emperor was smart enough to follow the Empress. He knew she was better than he. He moved up and down.

"Our best course is to surrender to the flier," the Empress continued. "The bird could have exploded. However, if we surrender, we will continue to administer since we know the empire. Djak cannot build many birds." The Empress was wrong. With energy, which he now had, and raw materials, which he could obtain, Djak could build as many entities as he wanted. Moreover, with remote sensors, either he or Djil could find out about people and economics in the two empires. Fortunately for the Empress and the other administrators and parasites, the error was irrelevant. The interstellar travelers thought in terms of cultural change, first in Glemria, then on the planet as a whole. They did not think in terms of an Empress or her followers.

Shortly, each empire found through spies that the other had received a visit from a talking bird. Moreover, diplomatic correspondence from each crossed on the way. It was almost as quick as the spies' correspondence. The diplomatic correspondence from Fortenst talked about the undesirability of making an attack on Glemria. Ildong responded and pulled back from its request that the flying creature be placed under international control. The more advanced technology had deterred the less. War would not occur.

Advisers and the chief people in both empires, the Prime Minister in one, the Empress in the other, were confused. None had the history, legends, or stories to tell them what to do. None understood that they and their successors would experience a major paradigm change. For one, they could no longer think in terms of a you-win/I-lose or a negative sum situation. At least part of the time, they had to think in terms of a win-win, a positive sum, situation. It was an 'out of context' problem.

Their history of fighting each other, their legends of strong warriors, their stories of fighting mythical beasts did not help. The stories were all about being the foremost thugs, about gaining more or less immediate rewards through war, and about setting up a government. The stories were not about losing. Even reports of social failure were of little use. 'Always,' emperors, empresses, ministers, and supporters who had heard of the warning thought erroneously, 'social failures occur in lesser countries.' They knew, correctly, that primitive societies lacked the level of physical technology possessed by the two empires as well as by Glemria. However, it was not the physical technology that counted; it was the social technology that kept the hexapede leaders from understanding.

It was not that they had met a vastly advanced technology, one that could destroy their planet, although they had. After all, even their lesser technology could destroy. If hexapedes did not advance, however, it was unlikely they would destroy the whole planet. Nonetheless, given their level of advance and the minority who engineered even with-

out the interstellar travelers, the physical technology produced 'goods,' which other hexapedes used — that would transform their world. Large quantities of water, for example, would be used in a large number of industrial processes. The change would not happen quickly. It would take awhile. The social technology was against it; but change would happen.

On the one hand — the old, human phrase was familiar to the interstellar travelers even though they could control up to twelve hands readily and each hexapede had six — neither Djil nor Djak wanted the hexapedes to make the same mistakes as humans. The two did not want them to pollute as much as humans or use up as many resources. On the other hand, the hexapedes could not return to a pre-agricultural state, not peacefully. Even with their low population density and low total number, such a return would cause many to starve and others to fight. Some would be killed. Nothing would be just. Agricultural technology was the problem. Even returning the hexapedes to a previous state with almost the same level of technology would be unjust.

Djil and Djak did have a mechanism to move the hexapedes into a previous state: they could build non-sapient yet intelligent robots to prevent the hexapedes from using their current technology. (If they were not watched individually, they would build devices secretly. Moreover, their current technology was so incomplete that it would be almost impossible to prevent improvements.) A huge number of robots would have to be built. They would have to be advanced and the hexapedes retarded. The hexapedes could not produce more than a little with their current technology and much would be taken from them. They had few contemporary material goods but not as few as in their past. Still, if the outsiders wanted to prevent advance, the hexapedes would have to be pushed back.

One mistake that Djil and Djak knew about was humans' use of fossil energy, like natural gas, petroleum, and coal. It was a finite store of solar energy, the use of which caused climate change and poisoned people. Perhaps, in their future the hexapedes could avoid coal, petroleum, and natural gas or not use much. In any event, only countries with a more advanced technology than any current hexapede country would use fossil fuels widely.

Even if the sources of coal, petroleum, and natural gas were in backward regions, producers who could not be backward would pay fossil carbon taxes if they were forced. Humans had not forced such taxes onto fossil producers for the longest time. Instead, humans had permitted users to dump carbon dioxide and the like into their planetary atmosphere without discouragement. Pollution was subsidy. They had permitted their coal burners to exhaust uranium since it did not burn and was part of solid coal. It was as if none, or 'few' to be more accurate, of the then humans realized that people had grown so rich and numerous that they had more than a local or insignificant impact. Of course, the impacts mainly came from people they did not know but

that was expected. Humans had a major planetary impact dating from less than a few centuries after their industrial revolution. Presumably, unless enormous numbers had died in the meantime and the news had not yet crossed interstellar space, humans still had a planetary impact.

If neither Djil nor Djak killed many hexapedes, if they did not take away much of the property of the remainder, the hexapedes would advance. The hexapedes could add to their use of other non-renewable resources besides coal, petroleum, and natural gas. For example, they would gather on-planet metals. Moreover, as humans had for several generations, hexapedes could consume renewables faster than they would renew. In other words, the hexapedes could overfish; they could drain aquifers. Djil and Djak expected fish and aquifers to be devastated. Neither knew about forests. The known need for one kind of tree to produce a nutrient might suggest that all trees be saved.

Chapter 9

Djak had already sent fliers across the ocean but that was not known to most. Nobody knew for certain except himself and Djil that he also spied on Glemria. Djinbit knew about the embassies; he suspected more, but was unsure.

Through his spies in Glemria, Djak found that iron and steel producers used mechanical bellows that gained their energy from fast rivers and year-around streams. The procedure meant the amount of air was controlled. At the same time, the hexapedes burned their equivalent of wood. However, the air was not preheated. Because the amount of air was controlled, when it burned, the 'wood' was mostly converted to carbon monoxide. Until the hot gasses reached the ore, the burning wood lacked the oxygen to convert its carbon monoxide all the way to carbon dioxide.

Djak liked the bellows and the wood. He would have to introduce preheating. Wood did not grow very fast but was safer to burn than any fossil fuel. A fossil fuel dumped fossil carbon into the atmosphere. Combined with oxygen to form carbon dioxide, it changed the climate. Sustainable wood also burned to produce carbon dioxide, but the carbon was taken from the atmosphere in the first place. There was no net addition.

He also thought that for efficiency the works should be bigger. Such a scheme had problems. Each iron and steel plant would consume an enormous amount of wood (and other growths). Unlike those in the past, the new works would be permanent. They would not go to the sources of carbon and iron. Indeed, since the source materials were expensive to transport, modern works had to be by water so the hexapedes could ship them in. Slow moving water would not provide the energy such works needed at a cost anyone could afford. Fast moving water could, but ships that went against the current would require more energy, too.

Mines needed to be free of water, too. They weren't always near rivers or streams to provide energy. They weren't always in windy spots, either. Consequently, Djak passed on the humans' information, slightly modified, about steam engines. He felt he must. He wanted mines. He wanted somewhat efficient iron and steel producers, too. They had to have pre-heated and blown air. The works would be big and the overall cost of production less. He would have to make sure the price dropped, too. Steam engines are independent of location. Djak did not think hydroelectric power and powerlines would be cheap enough initially.

Fossil carbon in the form of coal was a serious competitor to wood. With low taxes, it cost less. Such fossil carbon could provide fuel for steam engines as well as provide it for ore. When fully burnt, it turned into carbon dioxide, a greenhouse gas which resulted from burning coal in air. For several generations, the impact on the planet of extra carbon

dioxide would be small. Also, it would not matter to people on the whole planet that the coal also dumped uranium. Even the ashes that vanished into the air would be small. Moreover, governments would like revenue; coal could be taxed. Fossil carbon would come from new sources. They would be simple to tax since mines could not be hidden to orbiting satellites. 'Actually,' he thought, 'taxes should keep the price of coal higher than that of wood and other renewables. There should be no income from such taxes. They will discourage coal mining. Only illegal imports will be dangerous.' Although smuggling could not occur for awhile, it would eventually. Djak thought for a moment. 'My satellites can detect mines all over. I can track the output to the ships and if they don't pay import taxes, which would prevent selling coal, I can tell the police.'

'On the third hand' — Djak decided he liked a body with six hands; he had been thinking of untaxed coal as a cheap and dense energy store feeding steam engines. 'Energy store' and 'steam engines' made two items; 'cut trees' made a third — 'trees should be replaced,' he thought, 'or else cutting should be taxed heavily. Otherwise, we will see too much deforestation even when the hexapedes think about forests over a longer time than most humans.' All imports of charcoal should be taxed, too. Otherwise he feared that it could become cheaper to import charcoal than to cut trees locally.

A copy of the amount taxed could be sent to countries that had replacement procedures for cut trees. Such taxes could be called tariffs. The tax would higher if the paperwork claimed that a country lacked replacement procedures. Those who had records of having paid taxes should get their money back from those countries. Receiving money should reduce smuggling. Of course, in a corrupt country, sellers could buy false records illegally. It would be necessary for the government to prove it was receiving taxes for cut trees by paying out the money from a separate account than the rest of the taxes. In addition, to send charcoal, shippers would have to have more capital since their ships had to be bigger. Charcoal took up more space than the luxury items that had previously gone long distances. More capital would give the shippers more power. Ships need not go to ports with customs' agents. However, satellites and non-sapient computers could track all the ships. Djak could give 'hints.'

'Indeed,' Djak thought, 'all new taxes should have a foreign component. We can export our laws. And being new taxes on new items, they won't be the result of deals between lobbyists and government!'

In addition, along with rivers and streams, steam engines could operate electric generators. Hexapedes had not yet discovered electricity or its laws. Did Djak want hexapede seekers to spend time discovering or did he want rapid change? Would there be rapid change? In any case, generators would accustom the hexapedes to electricity. With the requisite distribution, the convenience of electric motors and electric light would cause the hexapedes to move to hydroelectric, wind, and wave

sources of energy early on, all sustainable and solar. Copper wires were already good enough although not as good as they would be eventually. Wire production would have to increase dozens and dozens of times. Electrical insulation was already made, albeit for other purposes; its production would also have to increase dramatically.

Djak could also check ores so he could better define other procedures to iron and steel making besides adding limestone, which the hexapedes already did. They not only failed to detect phosphorus, which made the resulting iron brittle in cold, but did not know of several elements that made the resulting alloys better; for this, Djak figured his 'action from authority' was reasonable.

In any case, with steam engines, Djak could safely provide information to create wood working machinery. With better machinery, the industry could carve big items like doors and small items like toothpicks. A mechanized wood industry could make them at affordable prices.

He could devise local textile machinery. Moreover, people in general could fund themselves and operate it together. That machinery had to be built. There was sexual dimorphism, a little of it, among the hexapedes. Rather than by smell, he and they could tell the difference between men and women by looking at them. Djak decided he should think in terms of women. They already spun, wove, and sold what others had grown or collected. With the first mechanical spinning and weaving devices, powered by steam, women could sell textiles readily, since their costs would be so much less than anyone producing in the old ways. Production and productivity would rise. Some women would become rich and powerful. Others, both men and women, would be put out of work.

Eventually, the price of cloth would drop. The producers would suffer, especially those who were poor. By then, Djak hoped, the new institutions and the new concentrations of money would enable the leading hexapedes to change focus and everyone else would follow, especially the poor. Djak also hoped that hexapedes' factories would be better than those of humans.

Sewing with a machine would be cheaper, too. A sewing machine could be made with metal and powered by a treadle. None needed the kind of energy that textile machines required. Djak could introduce that device.

Most of what Djak planned to introduce was an extension of what was already known. Almost nothing required a change in hexapedes' underlying beliefs, a paradigm change. Only electricity did. Well, he was sure that the social technologies required a paradigm change, too, but at the moment he was thinking of physical technologies. Electricity was invisible and electrons flowed through solids, unlike water which was visible and flowed through hollow pipes. Djak still did not know whether he should introduce electricity or wait until a hexapede scientist discovered at least a few of its laws.

He finally decided to disclose everything. There would be paradigm changes and resistance. For most people, any paradigm change would take time; maybe he would have to wait for new people to be educated. As for resistance, that caused by pollution in particular, in the present the hexapedes could not cause as much damage as in the future when they would be more developed economically.

Djak also created and published a hard copy book, *The Implications of Technological Change*. He wanted to tell people about the future as much as he could and named himself as the author. Consequently, a good number of people read it or at least looked at it. He included descriptions of the physical technologies, like sewing machines. They were skipped over by many who read. He also included descriptions of the sociology. The book told of increasing material inequality since some people gained more from economic change than others. People and societies could go down relatively or absolutely, both among the already lost and among those who had already won or thought they had. On another hand, those who funded practical, new technologies could gain. On yet another hand, the prices of steel and the like would drop — eventually. That meant almost all would benefit except those who did not adapt, such as the powerful who persisted with the old ways and the poor who followed them. The book caught the attention of Rildung, a rich and powerful hexapede who read it all, including the parts on physical technologies. He talked about the book to his friends,

Djak wrote about the finite size of the hexapedes' planet. Without using their renewable resources at rates less than they were renewed, without recycling unrenewables, and without eventually expanding into outer space and gathering resources there, the hexapedes would all lose. That was hard to consider. Rildung realized that he understood, but few of his friends did; or few appeared to. Moreover, the durations were long, stretching beyond the lifetimes of his children or grandchildren. Most of his friends said they still thought of the planet as big. Perhaps that was why he was lonely, Rildung thought. Or maybe his friends did understand the finiteness of the world and paid no attention — after all, the planet was big and would not be hurt in the immediate future, in one lifetime. Perhaps, they did understand, realized the time went beyond their grandchildren, and wanted more income now.

Djak said that humans perceived numbers, distances, and times in logarithms, a kind of exponential. That is to say, what human people perceived themselves as seeing and hearing was compact. Perceptions were condensed. Compactness is a characteristic of logarithms. Humans, at least those in 'advanced' countries, were 'educated' so they saw and spoke numbers as a line with arithmetic markings, like a rope used to measure distances. Arithmetic measures are not logarithmic measures; arithmetic is not compact. Perhaps hexapedes were like humans.

Humans would count a few objects and estimate the number of many. Only occasionally would they count on a rope or its equivalent, such

as a straightedge with distance markings, a ruler. No one perceived logarithms. Moreover, when estimating, humans used the word 'about' or an equivalent. In any case, the length of the words did not grow as much as length of the number line. Even the largest numbers that educated humans could think of in their imaginations were spaced along a line equally distant from their neighbors. That was why they did not perceive dangers. "Perhaps," Djak wrote, "hexapedes are not so educated."

In addition, wrote Djak, "Exponential changes can happen quickly, in a dozen or two dozen years. Local changes can add up to be global." Except, he said, "We find that those humans who are educated to see numbers on a rope don't see exponential, dangerous changes that take two dozen years. And those who perceive in logarithms think them small.

"That made sense for a human population at the beginning of the species. After all, their killers were local. They were often visible animals like tigers. To survive, humans had to dodge and escape their killers. There were the unknown killers, too, such as microbes, who were many. They were truly unknown and neither here nor there." (Djak said that tigers were the Earthly equivalent of a fierce creature that the hexapedes knew; he had to explain microbes.)

"Hexapedes do not impact the whole planet now, but they will eventually." He ended with a moral statement: "Getting the balance right at the beginning is best."

Chapter 10

Not long after, Djil talked to Djinbit. “Djak and I have decided to give hexapedes, those in Glemria, all human scientific knowledge that we know up to electronics, more or less,” she said. “The knowledge will spread. Djak is going to print textbooks and encyclopedias.”

“‘All human scientific knowledge?’” asked Djinbit.

“ . . . that we know up to electronics,” said Djil. “ . . . a summary, actually, that will look huge to you. There is too much knowledge to print it all, particularly knowledge that we consider recent and you consider lifetimes in the future. We, in particular our spaceship in the Belt, have miniaturized records of just about everything that has been published on Earth. We can translate the critical parts. We will print a little that is more recent than electronics, too.

“How do spaceships work?” asked Djinbit.

“Ours is interstellar,” said Djil, “and is very small, about a tenth of a meter long. It is embedded in a solid hydrogen and liquid helium-three ball about two meters in diameter; the hydrogen is converted to gas for the magnetic field and also slowly erodes during the trip and the helium-three provides us with energy. We were pushed out of the Earthly Solar System by powerful particle accelerators, which acted on the magnetic field that we generated. Acceleration was very high. By the time the particle accelerators turned off, the fast moving particles had expanded to more than a dozen times a gross times a gross meters. All the particles were deflected by our magnetic field, but not directly back. We slowed down by running against your sun, which also emits particles, although they are much slower than particles from a particle accelerator. We came very close to the sun, yet protected ourselves and our remaining hydrogen and helium-three with multiple layers of very thin metal. In a vacuum, they reduce the heat nicely.

“We foresee two problems with giving you the information: firstly, you won’t catch up with the technology for more than several hexapede lifetimes. Secondly, hexapedes won’t ever create self-discovering scientists. The second is our biggest problem.

“Your habit — by ‘you’ I mean your whole species — your habit will be to follow humans. It is like the human statement from before overfishing or pollution, ‘If you give a man a fish, he will eat for a day; if you give him a fishing rod, he will eat all his life.’ We will be like those who give a short-term gift, a fish rather than a fishing rod, except in this case, it will be knowledge and will last for more than a few of your generations.

“You can have more historians, archaeologists, and mathematicians. That is the good news. Historians and archaeologists look at the past, which already exists. We humans know very little about the history and archaeology of hexapedes — only what Djak and I have discovered. And famously, mathematicians require only an education, pencil, and

paper. Sure, computers help, but they are not necessary, especially if the mathematicians are going to invent new patterns, new ways of thinking.

"Other disciplines depend too much on technologies that won't be possible for several of your lifetimes. That is the bad news. Astronomy is an example. Djinbit, no one will be able to build the necessary sensors and computers during your lifetime. We won't replicate them and you cannot import them. Earth is too far away. We will teach you to understand a spectroscope and maybe you'll be able to record images that are not hand drawn. To build telescopic sensors as sensitive as ours — that will take more than your lifetime.

"You, Djinbit, and other astronomers will mainly check that we are right. That is useful, except I suspect we were right. It is only the current discoveries that are controversial. No one knows who has the best explanation.

"You will not be able to obtain the requisite sensors during your lifetime and I know that you are not a mathematician. We will teach you about spectra. Unfortunately for you, for us that is old knowledge.

"Many new astronomical discoveries depend on very faint spectra. You will not have the right sensors and computers to exceed humans, not for several lifetimes. That is the problem. You will still be our conduit; you will have a living. Still, I worry about you and about others. It is not good being so much behind. Our own scientific engineering looks like magic to you. We can and will explain it to those who like reading and are interested; that is what the printings are for.

"Unfortunately, you don't even have the concept of modern engineering; the word is about building or growing intentionally. Engineering is a different specialty than science; that is to say, different sapient entities pursue engineering rather than science.

"Scientists try to seek and prove to others that what they, meaning scientists, have sought is real. Well, more accurately, they try to prove that their explanations are real. Mostly, they are into proving. After all, most of the time, what they seek is wrong; the explanation is wrong. Proving can be dull although it is what distinguishes a science from a superstition. It is better to understand reality than to imagine falsely. That is why human scientists talk about 'hypotheses,' 'theories,' and 'laws' with increasing degrees of evidence. Scientists think in terms of the probability of an item's truth. A well-evidenced discovery changes probabilities. That is why physical 'laws' are overturned.

Unfortunately . . ." Djil paused for a moment. "I seem to be saying 'unfortunately' frequently," she said, "you hexapede astronomers won't have a chance to seek. Even if the discipline is mostly about proving to others, a few must seek or everyone goes somewhere else. What are we going to do?"

Djinbit responded. "Focus on the historians, archaeologists, and mathematicians who can be true seekers. Say that the other sciences

are going to be purely proof-oriented for several lifetimes until we catch up with humans; no hexapede scientist will seek. In the other sciences, mine included, seekers in the first generation will suffer. I will suffer. But at least we will see what the humans have discovered. There are very few of us.

"I will be your conduit. How are you going to do that? The word 'conduit' implies that you are not going to disclose everything at once. The word forms a contradiction with your previous statement, about printing 'all human scientific knowledge.' "

"You are going to be a different kind of conduit," said Djil. "As far as possible, we will disclose everything up to electronics, mostly, all at once, as quickly as we can. Where necessary, we will provide more modern theories since they will be better. Translation will take awhile, though not long since we can make speaking, reading, and writing yet non-sapient robots. Your paradigm changes — I'm talking of all of you in the species now. Also, learning the details will take more time. That is one of the reasons we will stop at electronics. The whole process will take more than a couple of generations before you are better than we technologically. As a conduit, you personally will have to be a teacher who explains a paradigm change and a few of the details."

Chapter 11

Djak walked outside the city. He left the photovoltaic sheet in the courtyard along with a controller and a battery. He could have walked out at any time, but he wanted to persuade the hexapedes; so he waited until he had permission. Glatist and a troop of cavalry accompanied him. Djak went to the observatory. There, he pretended to meet Djinbit for the first time.

Djil had warned Djinbit and prompted him on what to say. It all worked out. Djak did most of the speaking. He made a small device, which could come into the observatory. He claimed he was not in it. It had tentacles and six feet. Djak told Djinbit and Glatist that it was non-sapient. Glatist presumed that Djak could communicate with it in a hidden fashion or, as Djak had explained in the local language, 'by magical communications.' He could make it talk. Djinbit already knew of 'radio.' Since he was pretending to know nothing, he followed Glatist. What the other members of the cavalry thought was not known. Their expressions were frozen.

Djinbit had no trouble talking about mirrors. When Glatist was not looking, Djak, or rather his non-sapient robot, pretended to fix the telescopes. He also said in a voice loud enough to be heard by Glatist and other cavalry, "You will be our conduit to other astronomers." Djinbit thought Djak had been smart. 'Djak now has a reason to go outside the city if hexapedes like Glatist presume the magical communication is limited to very short ranges.'

Then Djak's robot said, "While I was converting the legs and mounts on your telescopes, I also converted your mirrored eyepieces to multiple lenses in tubes of the same size, so you can change them to have higher and lower powers. All this can be done by your craftspeople, too, so I made instructions in multiple copies, but not many copies. Fortunately or unfortunately, I think I have made a sufficient number of copies." The copies included tests.

They all left the observatory. Djinbit understood he did not have to keep anything about the telescopes secret from Glatist. He felt relieved. He was now 'official' and Djil was still hidden.

Djak went on to say, "I'll leave my robot out here. Glatist, I'll have to come out here every so often to make sure it is working right." Glatist smiled at that. He thought the robot was as likely to break as any other complicated hexapede machine. He did not think of it as a nail that could be bent out of shape or disintegrated by acid or time yet mostly stayed the same. Even though it was highly complex, the robot was closer to a nail than to a hexapede hammer, whose head might come off. Djinbit thought, 'Now Djak has another reason to go outside the city.'

Djak spoke again, "Djinbit, if my robot stays, I should make it look like a hexapede and also give it a camera and screen. Is that all right

with you." Both words, 'camera' and 'screen,' were in Djinbit's language. 'Camera' was from 'camera obscura;' 'screen' was an even older word.

Djinbit looked at Glatist, who nodded slightly, that is to say, he moved up and down a little bit. Djinbit said, "Yes." The robot went into Djak — it was all very visible — and then came out of the ship looking just like Djil and her sheet.

"What is the use of that sheet, or screen as you call it?" asked Glatist. It promptly showed him a picture of the barracks, which were in town, and then a moving picture of Glatist himself. That it was a moving picture could be seen by the movements of another hexapede behind Glatist. That it was right-left reversed could be seen by the side of the observatory; it was not where a mirror would have put it. Glatist stared at the moving picture for a moment, looking puzzled, then waved at himself. The image waved back; it was not on the same side as on a mirror. Glatist stopped looking puzzled. The image was like a very good 'camera obscura' except its top was up. He moved up and down, thinking to himself. Glatist thought about the image a moment more then asked Djak, "Can your screen show cartoons that you draw, like an artist draws a still picture?"

In response, the screen showed a geometrical demonstration about right triangles. "Yes," said Djak. The picture showed the geometry in steps. Finally it was still. Glatist did not know whether his image would be recorded and kept, but he suspected.

Djinbit felt happy. The small creature now looked like Djil and the screen looked like the sheet. Just as Djil advised, he had got permission from Glatist. In addition, Glatist had figured out that Djak could draw on it. That was unpredicted.

The robot spoke in its high voice, "I can make more instructions, too." It looked at Djinbit. "Do you mind if I make a small hole in your lawn?" "No, I don't care," said Djinbit.

The robot holding the screen promptly made a hole. He put moss, dirt, and at least one stone into himself. Djinbit was not quite sure how he took the material. He then produced what looked to Djinbit like a gross of printed pages. Djinbit was not sure what the printed pages were composed of. He did not know that the robot had built the pages with some of his own atoms, too. The robot collected a mass similar to the pages he produced; he did not collect similar atoms. "These are instructions," he said. "I did not produce more about telescope making because I expect you have enough of those. Instead, I produced instructions for better saddles and harnesses and for better fireplaces. It was not until I finished that I remembered that you don't know about fireplaces, yet."

Djinbit gave the pages to Glatist. "You are going back to the city and you know the saddle and harness makers better than I. You know the fireplace makers, too, which I don't at all. Please distribute these."

Glatist smiled wryly and took them. “We don’t have ‘fireplace makers.’ In areas like ours,” he said, “people build their own fireplaces. They are their own masons. Or fireplaces are made by contractors when they build a house. I will give all these instructions to the saddle and harness makers. They will pass those on fireplaces to the contractors and the astronomical instructions will go to the proper craftsmen. They will gossip to everyone else.” Djinbit nodded.

After Glatist and Djak left for town, the robot and its screen went inside the observatory. Djinbit followed. There he saw Djil and her sheet, looking and sounding just like the robot and its screen. “Yes,” said one — only by localizing the sound could Djinbit determine where it came from; this was Djil — “the robot looks just like me. I’ll pretend to be it when other hexapedes come, like Glatist and his soldiers.” Then, the robot looked at Djil and spoke: “You can convert me into other designs. In addition, I made a small hole outside. You can make more holes and take more atoms presuming Djinbit permits you.” ‘Gaining permission is why they are speaking rather than communicating with magic,’ Djinbit thought. ‘They are communicating with me as well as with each other.’ He moved up and down.

“Most of what you should have,” said Djil to Djinbit, “won’t take much new material: better fireplaces, for example, will take little. Saddles and harnesses won’t take anything from us. Saddle and harness makers will make the changes, which are small anyhow. Djak got the ideas from our ‘horses’ although your saddles and harnesses are good anyhow; ours also have been good for quite some time.”

“What about bricks for chimney throats and metal for the dampers?” the non-sapient robot asked. Seeing Djinbit’s confusion, he explained. “The throat is a constriction that reduces smoke in the room and increases efficiency. It took humans many, many years to discover it and you hexapedes haven’t yet discovered it. A damper is a metal gate in a chimney that opens and closes.”

Djinbit wondered how the travelers had learned about hexapede chimneys. He then realized pictures and words were in the dictionaries and when he was not inside the building, Djil or the sheet could have looked into one of his chimneys. They could all communicate by radio. Djinbit did not know anything about radar or other mechanisms for seeing inside what would be considered solids by those who only had regular senses and memories. He knew nothing about cosmic rays or neutrinos and how they could give a tomographical view of the surroundings to any entity with the right algorithms, the right detectors, and a good memory.

“You will mainly close the damper,” said the robot, “to keep out the rain. It is also designed to keep out bugs and to keep in heat.” The robot did not say anything about carbon monoxide and carbon dioxide. “You are unlikely to remember to keep the heat in even though the damper will succeed. You are unlikely to have such a motivation. You

will close it when there is no fire in the fireplace. You can start a fire with the damper closed, but the smoke won't go up the chimney; it will come into the room."

The non-sapient robot turned toward Djil. "I lack metal for the dampers and have too few atoms of the right type for the bricks for your chimneys. We could dig holes for the bricks but we would have to move much earth to get additional metal."

"Or we could get it from Djinbit," said Djil. "I suspect we will have to dig holes for the bricks." Turning toward Djinbit, Djil asked, "As for the metal, do you have stores of it that people will not know the exact amount of?"

"Yes," said Djinbit, "in the junk room, which is more like a closet in the workshop. I don't know what is there myself." Metal enjoyed a high price, but not so high that Djinbit was pushed to leave his astronomy as he might have with rare jewels.

"A junk room is a fine source," said the non-sapient robot. "Meanwhile, when anyone comes, I will pretend to be a table. Djil can pretend to be me."

"I will make another table for you, Djinbit, if we use up too much substance from the robot," said Djil. "Do you know what you want besides better telescopes."

"Maps," said Djinbit.

"Don't worry," said Djil, "we will produce better telescopes and better maps for you. I meant other things. We'll make them all. You are going to be our astronomical conduit; please remember that."

Chapter 12

A day later, Djak speculated. He spoke only to Djil and he spoke by radio; none of the hexapedes knew his thoughts. He told her that the people of Glemria were conservative although not as conservative as the people in the empires. Djak observed more dangers in the empires and more corruption. Also, none knew the range of his radio. Those who knew about his warning to the empires thought he spoke through devices with more relays to cross the ocean than he had actually built. They knew he could build. Almost no one knew of speaking, non-sapient machines.

"Also," Djak said to Djil, "the empires provide few transfers to the poor and middle classes. Mainly they are transfers from the poor and middle to the rich."

"Yes," said Djil.

"The empires' cultures do not provide much for voluntary social services, like tithes. Actually, here we have sixths, not tenths, with half going to religious organizations, except in Glemria they don't have a single, state religion. Here — I mean on the planet as a whole — hexapedes give to their dependents, especially relatives. Most is to husbands, wives, and children who are dependent and not making an income. They are in a family. Glemrians give to others, too, mostly in their clans. Many give their clans more than a sixth in total. They give their closer family even more. In the empires, people seldom support clans or anyone beyond their immediate family.

"Conservatism is not be the only reason, but it is enough. In the empires, ordinary people try to conserve their families. There are fewer rich but more adequate and ordinary people here in Glemria." Djak paused for a moment. The pause was too short to be noticed by a biological human but was by Djil.

"In Glemria," said Djak, "hardly anyone jumps to the new technologies. Only a few businessmen see the advantages for them of more efficient iron works and mines." He was mystified by that failure. "Perhaps they are not quite as greedy as we think they should be. Or maybe they think the advantage will be only temporary. Most of those who can afford the new technologies wait to see what will happen. Only a few are like Djinbit, who definitely wants more. Except most of those few only want certain things. That characterizes Djinbit, too."

"Djinbit cannot afford to build an iron works, not even one with an old technology; and he won't collect, that is to say, borrow, the money or raise equity from others," said Djil.

"That is true," said Djak. "As for overseas, the leaders of the empires will discover that mathematics, science, and technology lead to engineering, which makes them able to fight better. So the survivors in the empires will encourage study. Well . . . initially, mathematics and science won't help engineers. They will eventually. I wonder whether

their overall transformation is going to hurt more or less than humans'? We shall see."

Djak figured that the interstellar travelers' guidance could make the transformation easier; he did not know what the hexapedes innate conservatism would cause them to do. Humans had used up all the resources on Earth that were 'economically recoverable for sale to the middle classes.' At least, the hexapedes could develop non-fossil carbon stores of energy. They should be different from the old time humans, who had consumed kerosene, gasoline, coal, and the rest, even natural gas! There was a reason: after deforestation and with low taxes, the fossil carbon fuels had been cheaper than the non-finite carbon products for several lifetimes.

If he been able, Djak would have smiled like a human or hexapede. He and Djil could not get rid of all the suffering that everyone experienced when they had backward technologies, but by discouraging fossil fuels and the like, they could avoid certain problems.

Djak was not sure what would happen in the empires once the hexapedes gained knowledge. There might be civil wars, although he would stop those that caught his attention. An empire, any country, depended on both armed force and belief. Changes might cause a war. Some beliefs induced young men to join an army. Indeed, they would go into the official military. Other beliefs prevented anyone from joining the military. Few of those people would engage in a civil war. Of course, some would fight. In the opposition, they would be a different group. In any case, such people would be more likely to believe in economic development, the kind of changes they wanted. Djak explained all this to Djil, who simply agreed. "Indeed," Djak said, "nobody wants a war of any kind, civil or otherwise."

"Hardly anybody," said Djil.

"Still, disagreements could be large. Those who refuse to go into the army are dangerous in new ways. Maybe a few will start a civil war." Djak did not know; neither did Djil.

On Earth, the United States had fought a civil war when the North was developing economically and the powerful in the South were still honor driven and feudalistic. There was a little technological development in the South, but not much. Their cities were developing but political power came from the heads of plantations in the countryside. In terms of timing, the conflict was the last chance for the South. Had it waited another ten or fifteen years, the North's manufacturing would have doubled compared to the South.

Overtly, the war was about slavery. No rich in the South were going to invest in advanced machinery and provide food, clothing, shelter, and no work for slaves. Rich Southerners thought of the poor people working for them, their slaves, as property. They were not going to waste potentially income-producing property.

"On the other side, the North had a labor shortage," said Djil. "At least, one human academic argued early on that the rich at that time invested in machinery because the price of labor was so high. In any event, the North barely won. Most good generals were Southern. White Southern soldiers were dedicated and fought for their leaders and states even though had the South won, few would have become rich enough to own a plantation or control a huge number of others."

Science would lead to technology and to engineering, which would lead to economic development and change. That was the latter part of human history. Djak expected the same among hexapedes. Empires would like economic development, since it would help survival, and dislike change, since it might hurt rulers.

As a practical matter among humans, early engineering did not depend on science. Fast economic development started with engineering — the design of machinery — not science. Engineers were needed, even though development depended on more than engineering. Initially, engineering was not a profession. However, later it did become a profession and did come to depend on science.

As for scientists, they had strange habits, like asking for proof and asking difficult questions. They would be a small minority of the total population, yet be visible. Adult scientists' strange habits would make it possible for children to be different, usefully different. Perhaps that is what Djak had to do: while he knew that most children would avoid being very different — they would just be a little different — he might make it possible for any child to be dramatically different.

That required education. Science required formal education. So did development, because parents could not teach their children new ways. Since many adults would not send their children to school, going had to be mandatory. That meant less child labor, not that such labor could involve more than the simplest technology. "Unfortunately," Djak said to Djil, "that labor is important to primitive farmers and peasants. They do not have good technology to keep animals in or out, like fences and scarecrows. They depend on people, such as children."

What should Djak do first? He was going to make wire cheaper. It would be fairly simple to make barbed wire. After it was seen, its design would become obvious. (He did not expect hexapedes quickly to absorb all the knowledge he printed.) Other kinds of fencing could handle animals that dug. On the other side, 'Why should a farmer or peasant or his landlord spend anything when previously he did not?'

Mandatory education should be first. Djak would have to persuade a host of hexapedes. In particular in the capital, he might not be able to convince people to avoid the kinds of schools they already sent their children to. Such adults could simply keep their children home. Some could hire tutors; others could create schools secretly. They could all join together to defeat the law. Moreover, enough farmers could vote and were sufficiently independent that they could be against schooling;

this was Glemria, after all. Consequently, he had to provide the farmers with a vacation for students when the farmers needed to use child labor temporarily, such as for harvesting. That meant students in the capital should also have a vacation.

Schools had succeeded in the past; would they succeed in the future? That was a question. Most children could and would learn to read. Like humans with reading, hexapedes needed formal education. In neither species was it like spoken language, which children absorbed. As for scientists, Djak was trying to change a small minority of children. He would succeed only if other students either accepted the minority or actively supported them.

The policies of the educational department had to favor seeking, science, even though all of its members were conservative and most lacked the temperament.

How would Djak do that? "I want the hexapedes to do it themselves," he said to Djil. "We can create enough robots to enforce a policy, but we do not want that. Such robots would be unethical.

"Besides, acting by ourselves will be impractical. Within a few generations, enough of the then living people could resist, especially if we fail to persuade hexapedes in the educational department." Djak spoke to Djil by radio.

"Hexapede parents may pass on their resistance secretly," Djak said. "It will be several of their lifetimes before resisters become sufficiently empowered that they can hurt a fair number of the rest, as individual humans can already, or cause a cascade of damage. Fortunately, or in this case unfortunately, such an economy is our goal.

"The future economy can be resilient, but the 'local' region will be bigger than now. It will have local and sustainable power generation, water, and other resources that will last forever — well, some metals and other elements will have to come from outer space. There is no way to avoid that. Fortunately, outer space resources will last a long time. Yet, even with resilience, many people can be killed by a suicide soldier. A believer does not cost as much as a computer to those who lack constructors and knowledge. We — by 'we,' I mean every intelligent person, both hexapede and human — we can prevent suicide soldiers' commanders only with a belief that disputes should be solved peacefully or in some other way that does not involve violence and by watching the behavior of those who do not so believe."

Djil agreed. She wondered whether Djak could create a policy to favor seeking in the current educational department? He had, in particular, to persuade the influential. Some of them were afraid of losing. They had already heard of and a few had read his book on the implications of technical change. The stated implications included losing.

Djak and Djil should encourage seeking in schools despite not expecting governments to favor large-scale funding for education. Eventually engineering would be pushed by governments, too, but maybe not by

a majority of people. Encouraging seekers was a thin reed, but both doubted that enough others would care strongly enough to oppose the travelers.

What non-hexapede physical technologies should Djak teach next or give examples of? He had already taught about steel and optics, although not much. He should do more with optics, he thought. The hexapedes could already build sufficiently accurate machine tools. New factories would make them cheaper. Nevertheless, he had to press for more measurements. The hexapedes had to produce more gauges, especially for length. Distances had to be measured. Their units were all different. He would have to decide on a single unit. At least, the numbers for time were similar through out the planet, except that some people's clocks did not have as good a resolution as others; they did not record as many numerical places. They did not have accuracy. They were based on the local day-night sequence, which did not provide any round numbers for human measurements. Fortunately, the Glemrians had clocks good enough for their current and near future technology, at least on land. They would have to build a great many more of them.

Djak had already written about gauges and interchangeable parts — he had written about everything — but he had only taught about some things. He had not taught about gauges. Nevertheless, he had to make sure that gauges were relatively cheap. That meant good gauging for the hand-made. Djil figured that interchangeable parts would come. For the machine-made, it meant a vast output of items with the same measurements. Put another way, machines had to be made from substances that did not wear away much. That was for 'hard' items.

In human history, money had been spent on separating seeds from fibers. As for wool, for all kinds of fibers, animal and vegetable, spinning changed slowly until suddenly a machine took over. Weaving become more important, too. Eventually, advanced machinery was invented, although the machines did not seem very advanced or complicated to Djak. Machines for weaving linen were constructed entirely from metal. They could weave less expensively than people although never as cheaply as machine-woven cotton once the 'cotton gin' became common, even when the cotton was imported from a distance and the flax, which wove into linen, was not. After a time, prices had dropped on Earth and he expected the same to happen on the hexapede planet.

Djak had records of the old, human, machinery as well as the new. He could adjust the machines to hexapede conditions so long as the price of steel was low enough. The spread of machine tools and gauges depended on price, too.

Machine tools and gauges would be demanded by the new developments. Consequently, their makers' incomes would rise until enough new people were taught. Djak expected their incomes to fall eventually but 'eventually' might be a long time. It would depend on the increase in the numbers of machine tools and gauges and the increase

in the numbers of makers and their productivity. The first would depend primarily on the speed of economic development, the second on education.

The empires had patent systems that kept certain hexapedes rich; that was their pay for supporting their rich friends. It was all mediated by governments. Glemria's use of its government to support ideas was better. People spoke of 'making public' innovations that would otherwise be kept secret, similarly with duplications. Djak did not expect the technologies for copying words, songs, and pictures to go beyond printing for several hexapede lifetimes. Put another way, at this stage of economic development, government-enforced restrictions on publications were not so bad, since presses were expensive but not their incremental output. Publishers would thrive as more people learned to read. Moreover, international copyrights did not exist, so desirable books traveled as well as the descriptions of desirable objects. Similarly, it was not bad to give temporary, government-enforced monopolies in Glemria for new devices that depended on new ideas, to give patents for them. On the other side, Djak doubted that anything in the human past deserved hexapede patents or copyrights.

Eventually, new technologies would make it easy to duplicate. Mechanical copying, which meant electrical devices to Djak, would make it very difficult to enforce government restrictions on copyrights. Very likely, hexapedes would try to enforce their government restrictions longer than humans, not to mention that they would try to cover more. It would take time. As far as he could see, hexapedes changed more slowly than humans. Moreover, there was nothing to prevent the hexapedes from acting as stupidly as humans. With more time, hexapede governments would try to restrict more with patents and copyrights. Patents and copyrights were devices as important or more important than those involved in steel making.

Djak decided he could not change everything immediately, so he did not do anything about Glemria's patents and copyrights. He would talk and write about future dangers. Also, he would make sure that all his information was available to the public for free use, including his adaptations of human machinery.

As for the two closest empires — Djak was not sure what to do. They would be more backward than Glemria, at least for a long time. Nonetheless, they had large populations. He had to make sure that 'fair use' was big in both of them as well as Glemria and the other countries. If he and Djil were not around, even with the ocean as a defense, one of the empires might conquer Glemria while fighting the other. They were backward but not weak in hexapede terms. For the longest time their bigger populations would help them. In any event, the countries' leaders did not want to lose. Consequently, they would accept some changes. The use of weapons would not benefit ordinary people, but empires would produce weapons locally. Ordinary people would make them, so they would benefit by the jobs and lose in the wars.

Djak said to Djil, "In the beginning, scientists should focus on reductionism; they will not be liked by those who prefer synthesis rather than analysis. They will certainly not be liked by those who think about everything mechanical in terms of metaphors based on life."

He continued, "However, I can introduce the study of ecology. Hexapedes' mathematics already has the beginnings of graphs so it can handle the beginnings of ecology. By graphs I mean nodes with lines between them, not informative drawings, although they exist, too.

"Ecology is not reductionistic and can be understood with metaphors based on life. The details of natural history, which is to say the details of natural selection, depend on analysis but understanding the whole depends on synthesis."

Chapter 13

Djil thought for a moment and then asked Djak over the radio, "What about the local powers, especially those in empires? They are mostly feudalistic. Also, some of them are less knowledgeable or less competent than their Prime Minister or Empress. Will they oppose change like humans?"

She went on, "In general, local powers are traditional rulers. Among humans, they favored false beliefs. I suspect the same is true among the hexapedes; after all, beliefs are cheaper than force. The beliefs keep rulers in power like chickens at the top of a pecking order. Local rulers may themselves believe. That makes them more convincing. Indeed, they may believe in a supreme ruler who is not their Emperor or Empress. Glemria has some of the same beliefs but fewer people hold them as it is a relatively new democracy without many rich and powerful."

"Good points," said Djak. "Many local powers will be worse than high-level dictators. The very top may go along with beliefs but see it as a tool. Fortunately, local powers and the people they can persuade lack the personal empowerment of humans — they don't have the technology yet. Unfortunately, we will have to persuade the local powers. We will have to persuade them in Glemria, too. Also, we will have to persuade everyone lest we receive many demands. The hexapedes will think of us as the source of good objects, like houses."

"We are."

"Yes, at the moment; but we will not be here forever. We want the hexapedes to develop the technology, social and physical. So we cannot give them houses or other items of material technology, not in large amounts. We have to limit our gifts.

"That is true," said Djil. "We cannot give away everything."

"We are, or at least I am," said Djak grumpily, "going to have to do a huge amount of persuasion. It's not like printing instructions for new physical technologies. And I prefer physical technologies."

He had hoped to spend his next few subjective years exploring planets without intelligent life. Indeed, even when the stars and planets were old, the vast majority of life that he had expected to discover would be uncomplicated. If it lived, it would be simple. Of the options for living entities, that was most probable. He had not planned to persuade anyone.

"Djak, you can tell the hexapedes," said Djil, "about law, equality, and individualism. They will like being able to predict what others will do, which is what law does. They will like equality, since that prevents a few who are more powerful from interfering. They will like individualism, too, since that means they won't have to depend on people outside their friends and family. The last is dangerous since it could lead to an excess of selfishness. As far as I can figure out, the first two, law and equality, are safe."

"The first two," said Djak, "fit the mathematics of social structures. Equality matches the first and law matches the second axiom. A human, Alan Page Fiske, wrote about them in the early 1990s. He talked about four social structures. The first law is the determination of equality."

"Yes," said Djil, "I know."

"The second is about greater and lesser. In social terms, the second involves power, which can be a person or an institution. Although it can be otherwise, law need not depend on a single person and it can be more powerful than any one person. Law will be enforced by persons, but need not come from them directly. Individualism does not fit this scheme at all."

"I agree," said Djil. "Nonetheless, you will need individualism for your scientists. The rest can depend on their community."

"What if the 'community' includes a feudalistic power?"

"That is a problem," said Djil. "Or maybe ordinary hexapedes feel they are subject to outside forces whether they be social or physical. Then they may be able to ignore local feudalists. If it is social, an outside force could be a bigger; it could be a more powerful feudalistic power. If it is physical, it could be a climate disaster."

"I notice you have continuously said 'could,' a subjunctive," said Djak.

"Maybe they won't be like humans."

"The human leaders in powerful states never accepted outside forces or not enough did, not even imaginary ones," Djak said. "In order to preserve their power or gain it, they went along with whatever was there. On Earth, only those of less powerful states realized there were more powerful forces in reality. I agree that Glemria won't become sufficiently powerful for a long time. However, we are providing them with physical technologies, which will make leaders powerful. And what about ordinary hexapedes who copy?

"As far as I can see," he said, "the main desire we can satisfy is health. That is the main desire of both central and local powers among humans. They would like to consume more, but that is a small desire compared to their desire for doing what they can in health. Let me think." Djak stopped for a moment and then said, "I don't know whether medical organizations are possible; they might be." He paused again for a very short time. "Feudalists' threats will prevent many healers from asking too many questions, from being equal, or from predicting. You are right, feudalists will be a problem."

"What if we persuade most hexapedes to favor law, equality, and individualism?"

"How do you plan to do that without civil or international war?" Djak asked. "The local powers will push traditions, some of which we support, such as honesty."

"Honesty is a tradition?"

"It is in a small village. It is also an ethical principle, but that is different. In a village, reality is important. Otherwise, too many die in fantasies. They expect rain when it will not come. They think it is the wrong season; they don't think of drought. Powers prefer that those who report to them be truthful, too, even if they themselves are not.

"City people," said Djak, "have more complex moral lives than country people. I suspect it is because cities have a wider variety of people and you don't continually associate with them. After all, dishonesty is a form of defection and defection favors someone who is not going to meet the other person again. When you have repeated meetings, honesty is better."

"Honesty is always better," said Djil.

"Yes," said Djak, "but that takes a consideration of the totality, which few do. And, of course, there are those who don't know how to lie, but that is a different matter."

"We can bribe the local leaders with something besides good health," said Djil.

"How?" asked Djak.

"Most of the local leaders," she said, "control a good deal of land through the power of their government. Government, being 'good,' can engage in a land reform that pays local leaders for their land and permits the current peasants ownership. Land owned by the farmers on it produces more, at least among humans. Local leaders will be loath to invest the money from their bonds, so we won't have to worry about inflation."

"Inflation?" asked Djak.

"If all the former land owners invested in iron and wood works, prices would go up; that's inflation. But only a few will. The economy can handle that. The government will be creating bonds that the former land owners can spend. Of course, it will be transferring income to the former land owners who can clip their coupons."

"It will be transferring wealth to the peasants, who gain the land."

"Yes, you can look at it that way, too. In any case, based on our knowledge of the planet, its economy can handle a little extra without much inflation. In addition, we don't want governments to put the cost of the land on peasants; that was tried among humans under a Tsar and failed."

"Failure took a long time, a human lifetime," said Djak, "but I agree. When the Tsarist government did fail, it was disastrous."

"Not that the people in the government had nothing to do with the failure. Moreover, the assassination of a Tsar stopped reform for a generation or two before the government failed. All in all, everything was bad."

"That is how empires go," said Djak. He paused for a very fleeting moment. "Most humans prefer the first or second social structure; and

the first with its equality cannot grow beyond a few hundred because no one can learn the names of everyone. Only the second, with its distant authority, can rule more than a few thousand people."

"What about preferences for the third and fourth social structures?" asked Djil.

"They are much rarer," said Djak. "Reciprocal and market — that is the description given the third and fourth social structures. They become preferences, at least, I think so. Mathematicians say that reciprocal social structures or preferences, like those involving equal rights, contain only one mathematical operation and that markets contain two. The former enable Fahrenheit or Celsius temperatures since they depend on only one operation, addition."

"They depend on subtraction, too," said Djil.

"Subtraction is addition with negative numbers. Mathematicians consider addition and subtraction to be one mathematical operation. The second operation is usually conceived of as multiplication and its inverse, division, That is the case, even though multiplication is simply the addition of the same amounts one or more times, usually more. I suspect the critical criterion is to have two mathematical operations, at least one of which is the ability to handle ratios. Conventionally, they are called addition and multiplication. With two mathematical operations, engineers can say metal at a temperature of twenty-one Kelvin has three times the energy of the same hunk at a temperature of seven Kelvin, because the Kelvin scale permits that and neither the Fahrenheit nor the Celsius scales do."

"So are you saying that empires are based on the simplest social structure that can rule more than a few hundred," asked Djil?

"Yes," said Djak. "In addition, people who prefer the second social structure are the most common among humans. If you link that preference to those of the ancient Greeks, Aristotle referred to such people as 'proprietors.' We need them. Fortunately, everyone can understand everything. That is why people in general go along with democracies and markets. Democracies have equal rights; that is reciprocity. The fourth structure has markets in real estate and fossil carbon as well as in all the other saleable items.

"Equality and individualism provide for a kind of dignity. With changes occuring in less than a lifetime, the kind of dignity which humans learned as children fails for adults. In particular, no one can keep up with regards to knowledge. The dignity that comes from knowing a huge amount does not work. You must have a different kind of dignity.

"As for business: the people — I am speaking of humans, now — in successful, developing countries like the early U. S., tended to have a 'not invented here' attitude since their companies had been successful. That worked fine until their organizations slipped. At that point, people in companies should have focused on selling rather than keep their not-invented-here attitude, since they were second. It became important

to understand strangers; you — I mean humans in general — should have been directed towards others. Likewise, the humans I'm thinking of should have thought in terms of the larger community rather than just the business community since developments come from others."

"In any case, it is all going to change here," said Djil. "Poor authoritarians."

"Poor everybody," said Djak. "You need a future orientation, not one for the past or present. A future orientation succeeds only for the young and middle-aged who want what change will bring. The old die soon. A few will plant trees and such; most will not. At least, that is the way among humans; I don't know about hexapedes. Old humans who fully believe in an afterlife think about that, not about their successors."

"Hexapedes' population will grow for the next few of their lifetimes. Their age-structure is going to become younger."

"Yes, but I worry about more than the 'next few lifetimes,'" said Djak. "I am concerned about the time when there is no reason any more to grow. Indeed, when population growth is dangerous. After all, the planet is finite."

"You make it sound as if change is bad," said Djil.

"No," said Djak. "The wrong sort of change is bad; the right sort is good. In any case, we can inhibit the need for more people for armies by staying for a few hexapede or human lifetimes — in effect, we are immortal. Rulers will learn to fear our torpedos and such; just our presence will frighten them.

"We can bribe local powers with land reform. We can persuade national powers to favor mandatory education for their young. Technology will provide more revenue through taxes and it will provide changes that give an advantage to engineers and scientists. In so far as they are like humans, when women are richer, have more power, and feel they have more dignity, population growth drops. We can favor birth control. In any case, the hexapedes' population on this planet does not have to rise as much as humans' did on Earth. It is all doable."

Chapter 14

The local powers found a way to take revenge. They hated the interstellar travelers: they said the interstellar travelers were taking the hexapedes' independence.

In fact, the local powers spoke only of one interstellar traveler, Djak, since they did not know about Djil. They did not say Djak was an example of an advanced technology. Instead, they said he was the first of a wave of humans. Djak funded other hexapedes to say that the humans could not arrive for more than a hexapede lifetime and that few would come since they would have to be modified dramatically to survive on what was to them a heavy gravity planet.

There were even a few hexapedes who spoke on their own. They did not require funding. Being rational, they said, 'Yes, we are losing a kind of independence. However, since we now have the information to advance readily, we are not losing our kind of independence.' Unfortunately, more than a twelfth of the hexapede population in Glemria feared. Nor did they care for technology, advanced or otherwise. Indeed, they did not care for their own health, the improvement of which was one of the benefits of the interstellar travelers' advanced technology.

"Everything is going to change, whether we are here or not," said Djak to Djil by radio.

"Yes," said Djil, "and our enemies, their commanders, I should say, are against any change. We are a convenient target; at least you are so long as I remain hidden. Most of the commanders of our enemies are local powers who will lose, relatively speaking, from social and physical changes. In a sense, they are rational; they are trying to keep from losing. So far, they are mostly in Glemria, which means that violence is not necessary to change policy, which is what laws reflect. Glemria is unlike other countries, those which lack a democratic government. In Glemria, persuasion wins. In other countries, much of the time, violence wins. Ultimately, of course, violence comes from persuasion. Nonetheless, you can persuade an army, navy, or police to be violent much more easily than you can persuade them differently.

"On the one side," — Djil's body had more than two hands — "the other countries, all of which have authoritarian governments, will try to prevent social changes. That will be good for the local powers. Even if the governments help anyone and everyone some of the time, they mostly are agricultural inheritors and will expect to lose when the society changes. On the other side, everyone in the empires will want to survive. Local and national powers will have to accept physical changes. Even if the countries lack scientists, physical changes that are copied will help people below the local powers. At least, they will in the long run. Physical changes will lead to social, societal changes.

"All we can do is speed up changes that will happen anyhow and point out the mistakes humans have made. I am convinced the majority will want the new technology."

"That may be," said Djak. "However, rulers are a small minority. You have to be intelligent in all sorts of ways, even in, or perhaps especially in authoritarian governments. Nonetheless, a bad king or two of them in succession or three can keep ruling. The government can last for several generations. However, that government will run into insurmountable opposition either domestically or from another country, eventually — it could be a long time.

"As far as I can figure out, most humans want to be ruled. They prefer good government, but that is a different issue. And, as one notable document said, '. . . Governments long established should not be changed for light and transient Causes . . .' But authoritarian governments are brittle. They are strong until they reach the breaking point.

"Democratic governments are less brittle. They, too, can suffer war and defeat. Those taken over by empires become brittle. Regardless of the kind of ruling, without competition, those in government become worse, just like those in business. They try to continue as they were.

"I suspect the hexapedes are the same as humans," said Djak. "We need both competition and cooperation. Competition means more than enough potential rulers; some will lose. So there have to be careers outside of ruling that potential rulers can follow. Outside of Glemria, in the 'other governments,' that is not possible. Other than the military, there aren't alternative careers, not ones to make hexapede families wealthy for generations. That is what the rulers have. Originally, they were the military, but that was many generations ago.

"Now, the powerful see senior members of the military as alternative potential rulers. Military people have the weapons, the training, and the ruthlessness to win. So the powerful will pick the stupid and corrupt, but try not to pick such stupid and corrupt people that foreign armies succeed. It is difficult. So really smart people will not go into the military unless they figure they can act sufficiently stupid and corrupt. On the other side, there are no other good career routes in authoritarian states, not if you want wealth that you can pass to your son or daughter. So ordinary people will enter the military."

The Glemrian army was somewhat different. For one, it was larger than it had to be; it both protected the country and transfered income from the government to its employees including the not-so-successful children of the powerful. After all, governments originally depended on thugs that won. Besides, it was a customary transfer of income, so hardly anyone complained; and, the army protected the country.

Tribal groups insisted that all men occasionally be members of their armed forces. None were paid. Such forces were not very successful militarily except against other tribes; the men mainly used hunting tools and were not coordinated or well trained. Tribes were defeated. (In

armies, male hexapedes predominated before advanced technology became commonplace because most female hexapedes lacked the physical strength of males. The exceptions confused men, so they grouped strong females with weak.)

However, tribal groups, while not very equal, were more equal than agriculturalists, which had as officer thugs the sons of the powerful. They were other kinds of society. Eventually a government paid an army even in peacetime and required it to train more than any thug could on his own, except the sons of the very rich. An army benefited. In addition to having soldiers all the time, those in training learned to coordinate their actions and to cooperate. In military action, such an army was more successful than its opponents; so other countries were forced either to yield or to adopt training.

Before individuals gained enough technology, armies of thugs were the only way to destroy people's livelihood and to kill large numbers of them. Most had to be in a middle or bottom position in a ranking. Somewhat higher, but not near the top, were the stupid sons of the powerful as well as smart officers like Glatist. Officers could persuade ('order' was the term used, yet in the end, it meant persuade) the lower ranks to engage in the stultifying actions of their everyday life, like maintaining obsolete vertical walls, as well as occasionally killing and destroying. None might like doing what they were told to do, but they would do it.

"You cannot have a monopoly," said Djak, "and rapid technological change at the same time. People in a monopoly have a kind of cooperation, which shows itself to outsiders as stupidity. That kind of cooperation does not work when changes occur in less than a generation.

"In the Union of Soviet Socialist Republics, a one time Russian empire on Earth," said Djak to Djil, "and its predecessor of a different name, the early leaders were against markets, although they had to permit local ones. Russia did not have rivers and harbors like the United States, another continental power. The Russians were afraid of invasions from the East and the West. They were poor. Perhaps being against markets made a kind of sense. Markets imply competition which implies bankruptcy for businesses and loss of power for governments. All and all, competition implies losers.

"In so far as the leaders of Russia wanted to get ahead, they could not afford losing. That presumed the leaders were right in their physical technology choices. If the leaders were wrong, the country lost. This happened in Russia after changes became frequent, first under the Tsars and later again under the Communists.

"Followers can copy others; first movers cannot. The Tsars copied to an extent and the Communists did too. They won World War II. After rebuilding from the war, Russia and its empire went down."

"What are you suggesting?" asked Djil.

"Perhaps I need to focus on the cultural shifts needed, although I prefer not to. In a book of the early 1990s, *The Seven Cultures of Capitalism*, Charles Hampden-Turner and Alfons Trompenaars listed characteristics of humans that maybe make a difference in economic development. It was written for other reasons, but is significant nevertheless. One of the differences they mentioned is that humans needed analysis rather than synthesis, since their devices were going to be simple albeit more complex than here now. A human business should have hired a portion of the two-thirds or so, in some countries, of the adult population that fitted. Successful companies did in the countries that developed economically. Currently, most hexapedes are the opposite; at least, those I have met.

"Eventually, a hexapede culture will need an equal rather than hierarchical social system lest people fail to cooperate technically because they don't want to help those 'above' them. For example, in a human culture, when you remodel a device to use photovoltaics rather than burning or exploding in an external or internal combustion engine, you need a safety engineer, a performance engineer, a general manager, a cost accountant, a quality control supervisor, and a test engineer. That means a need for formal equality. Of course, some people are better than others. That can be dealt with. When they are all conventionally equal, you cannot put into a ranking order the safety engineer, the performance engineer, the general manager, the cost accountant, the quality control supervisor, and the test engineer. Also, rather than an ascribed status which is usually from past lives, that culture will need to favor contemporary achievement.

"Fortunately, in Glemria, hexapedes tend to generalize rather than to discover exceptions to problems; they are like successful people in societies in the early human industrial revolution. Unfortunately, successful human societies also thought of a business as dead, perhaps as a consequence of that belief. Many groups in early, successful human societies came to think of people as dead *resources*. When people are thought of as individuals, then companies of people, businesses, must be thought of as living."

"Why?" asked Djil.

"It's not logical," said Djak. "Perhaps I should change 'must' to 'are;' companies are not living, even though their components are."

"OK," said Djil, "that makes sense, although you should say that some components of businesses, their equipment and buildings, are dead, but their other components, their people, are alive."

"Moreover," said Djak, "when going through the early part of an industrial revolution, a hexapede culture should be in favor of speed rather than of synchronizing resources, although the latter will be needed, too. Most of their machines should be fast and dumb. In other words, a majority must understand primitive machines, which means analysis. Similarly, a later industrial revolution requires that most people look

towards synthesis, life metaphors, rather than analysis, so they can imagine tools that are too complex for minds. Synthesis is what the hexapedes have now.

"I suppose scientists should be inner directed; they will be anyhow. Engineers and the rest need to pay attention to other people, so they should be outer directed. Most are already, so we do not have to change that. It will be with synthesis and analysis that we will have trouble. We will have to change a majority of people from synthesis to analysis and then back."

"I am not sure that's possible," said Djil.

Chapter 15

In Glemria, taxes were not liked even though they were not a way to raise money for predators, as in other countries. The strongest opposition, who were the best organized, came from the powerful. A few of them supported mandatory education and thought their taxes should rise but not many. Regardless, the proponents were not well organized.

Besides opposition from people outside of government, which Djak expected against mandatory education, an accountant for the national government said, "We cannot afford to pay teachers, presuming they exist in the first place." Indeed, none of the Glemrian governments, national, regional, or local, alone or in conjunction with others, could afford the cost of a large enough program without increasing and collecting taxes. That a person in the national government spoke meant that many of the powerful heard. Taxes would have to increase to pay either teachers or borrowing (borrowing would put off the government having to raise the money now to pay teachers). It was not as if the current economy had unused resources that could be stimulated by deficit spending.

Djak intended first to encourage large classes and students teaching lesser students; that was how he was going to solve the 'lack of paid and adult teachers' problem. Nevertheless, taxes were still going to rise. In this case, 'lack of' did not mean 'none;' it meant 'fewer.' Neither Djak nor Djil had foreseen that many powers in Glemria would come out against higher taxes.

Education was not seen as an emergency, which would have influenced the powers. More importantly, no one had as yet become richer. The accountant for the national government was right. An increase in taxes meant the powerful and rich could spend less directly. Indirectly and over time, they would benefit materially from new teachers but they did not see that. They could see that a little taxation now could mean more later. Nor did they expect improvements in their own incomes, although they believed that non-powerful workers would gain. The powerful saw that such a gain for others meant they would pay more.

Djak decided that physical technologies should come before taxes. He did not want to argue. Besides, teachers would save a portion of their income in ways that would not be useful to anyone else; essentially, they would hide cash under their mattresses. That meant that even indirectly, powers would not get all their tax money back without economic advance. After enough physical technologies came into use, everyone's income would go up. Then he could increase taxes. He could have mandatory education, too.

Djak hoped that Glemrian culture would promote his physical technologies even if the local hexapedes were more conservative than humans. With respect to 'physical technologies,' Djak favored all the

technologies associated with weaving. Consequently, to be affordable, he had to reduce the price of iron, which directly or indirectly was used in the weaving technologies. That meant iron works had to be bigger. That meant steam engines. Fortunately, the hexapedes could build them.

Most of the spinning and weaving machinery could be built from wood, at least initially, so prices of iron and steel did not have to drop too much. Sewing machines had to be made mostly from metal, but even with a large number of them, the amount would be less than would go into future spinning and weaving machines. Less relevant would be improvements in saddles, harnesses, and optics.

Steam engines would cause changes, even with leather gaskets for seals. His both pushed and pulled, had good valves, and good controllers. Moreover, they had two cylinders and used a great deal of the lower pressure steam. It first went through a smaller cylinder, which was at a higher pressure. In other words, steam engines cost more and used less fuel than the first human ones. They were costly and efficient, although they would become yet more costly and yet more efficient with more advances.

'First,' Djak thought to himself, 'I need to order a robot to come in from the asteroid belt, orbit the planet, and look for mines and wells with various sensors. I do not want the hexapedes burning fossil fuels, not for making steel, not for steam engines, not for anything. A satellite should have active radar for all weathers, passive infrared for the night, and passive visible light for the day. I can then give hints to the police. Getting the satellite prepared should not take long. Indeed, I should order several, so that besides observation, I can communicate anywhere and find positions more readily.'

Since his observation satellite or satellites would come quickly, Djak could have the Glemrian legislature pass a law which taxed fossil fuel sources out of existence.

Even with the low technology they had, coal, petroleum, and natural gas would be cheaper than wood and other current growables unless, of course, the hexapedes employed taxes or truly invested in sustainable alternatives. 'Cheaper' would last for several of their lifetimes. Besides straight costs, 'cheaper' included subsidies such as dumping carbon dioxide into the atmosphere. It could take place with government-provided subsidies, too, but Djak did not expect them. 'Several lifetimes' was too long for even the hexapedes to foresee. Taxes, not subsidies, were needed now on fossil fuels. 'Best taxes be instituted soon,' Djak thought. It would be at least two hexapede lifetimes before hexapedes had an impact on the planet as whole. However, it was safer to create taxes before anyone's material income depended on lacking them. Djak hoped to persuade the legislature to do so soon.

Djak wondered what could be done without satellites. In most of the world, sapient rulers would control some form of empire although

they would not necessarily say that. Subordinates would be corrupt. At least, some would be; it did not take many.

'Could a low technology country with mostly honest people in it,' asked Djak of himself, 'avoid smuggling fossil fuels? To prevent such smuggling, the country would have to control its borders. Police have to be spread out among the domestic population. They cannot be concentrated at and near borders as they would be if they were only to watch illegal border crossings. That means a country should either have a large army and navy for its size or borders that discourage smuggling. A proper border guard would be an army or navy.

'Countries on this planet have porous borders; too many have sea borders that ships can land on. A few landlocked countries have strong borders; yet because of their current technology, their imports are expensive. Glemria has a larger army and navy than its population would suggest. It is not landlocked. However, the sizes of its army and navy are not big enough to patrol its borders well, especially its sea borders. Without satellites, it cannot stop enough smugglers.

'My hunch is that the sizes of the army and navy are to give government welfare to the children of rulers, even in Glemria, or perhaps especially in Glemria. Its big army and navy have nothing to do with smuggling. Children cannot all be capable. Moreover, the capable, regardless of their beliefs, tend to take over governments or try. Even those who are against governments find that a few others are in control of them. That is the human history and I bet it is the hexapede history, too.

'At least, I have satellites. To take care of them and to pass information onto the police, Djil and I will need to stay for several lifetimes. This will discourage hexapedes' self-reliance. They will depend too much on us. However, it is that or persuading the hexapedes to increase a wasteful portion of themselves — their armies, navies, and police — to counter smuggling of fossil fuels, a currently non-existent problem. Reducing self-reliance is better. After we leave, they will have to depend on themselves. Eventually, hexapedes will try to beat humans. Hexapede rulers in the Glemrian or a world government will have to persuade just about everyone in education that dramatically different people, even if they are only a few, can be helpful and should be protected. Such people, children initially, will become the scientists.'

Djak would tax fossil fuels out of existence; they were a limited resource that would only last for a few lifetimes at an affordable price. Besides, burnt coal would release uranium and the rest into the air; it was a polluter. He would mainly push physical technologies, such as iron works, which would make steam engines cheaper. Later he would try to persuade the hexapedes to favor other social technologies besides taxes on fossil fuels, such as mandatory education. 'The various physical technologies will change the culture.' He spoke to himself. 'They will have to end child labor, which depends on the kind of technology a child

can handle. Only the simplest and the most advanced technologies can be operated by children. The hexapedes aren't sufficiently advanced. Also, if human history is any guide, people acting stupidly can sabotage expensive machinery unless it is advanced. Consequently, any kind of forced labor is out, including slavery. At least, that will be the case in the next few life times. It will take several generations for people to catch up. It will take more than a few generations to create a sufficiently smart technology and to produce anything a child can operate. In any case, only a few will design machinery. I can do it at the beginning, but we are going to leave so we must support independence. Essentially, for a child, advanced technology has to be at the level of a smart robot.

'Will there be enough wood?' Djak asked himself. 'Certainly, there is now. But in a couple of lifetimes? Even with hexapedes paying attention to wood lots because of their dependence on a vitamin, modern physical technologies use enormous quantities of energy. If we want everyone to become materially richer, as we do, will there be enough? Wood and other growths come as solids and you can make charcoal out of them, gasses and liquids, too. Well, we'll just have to go with what is possible until something else comes along that is not as harmful as fossil fuels. Eventually, they will have electronics and hexapede-designed von Neumann machines."

Chapter 16

Meanwhile, Djil provided information to Djinbit. It was the same as in the textbooks that Djak printed but Djil did not expect Djinbit to read them quickly. She gave him maps of the planets and moons in his system, those he could see and several he could not. She gave him maps of planets and moons in other solar systems, too, including Earth's. "You won't have the technology to detect these planets for the longest time, much less make maps of them. However, knowing of them is useful. We came from Earth, which has about a third the surface gravity that you have." Djinbit looked puzzled. Djil said, "We weigh less," and Djinbit moved up and down. It wasn't that he was ignorant; it just took him a moment to make sense of the words 'surface gravity' in relation to a strange planet.

"You will have to say that these maps were given by us. We will give you lists of stars, as well: their locations and types, the best data. We will convert stars' locations to your place. I guess we will convert our parsecs to your years. In addition, we have what we call light years.' ('Parsecs' are an odd and old measure based on the distance from Earth to its Sun, which defines its year; we also have 'light years' based on the human year.) Stars are far apart; it takes years for light to travel from one to another, whether it is your years or human years. We will keep stars' types since you don't yet know how different they are. Our type names are not the best since they grew over human generations. Indeed, some were originally wrong. 'A' type stars, for example, are dimmer than 'B' type stars. Nevertheless, the current, overall form is logical and consistent."

Djil presented Djinbit with a list. It was huge. Yet Djil said, "The coverage is incomplete." She explained, "For example, it does not list stars in other galaxies. You don't even know what galaxies are! Moreover, this list is more than that of stars; it contains nebula including galaxies. We expect you will be able to detect many of them."

Djinbit noticed that the list's precision, and therefore, presumably, its accuracy, was much higher than his. He asked Djil, who said, "It's good that you know the difference between precision and accuracy, between the length of a number and whether it is truthful. There was a period among humans when that knowledge faded. Fortunately, it never vanished among scientists. The numbers you see are both accurate and precise. In more accurate instances, they only go out a certain number of places. Otherwise, the numbers would be too long."

While studying the list, reading about astronomy, and learning more from Djil, Djinbit felt he was in school again. In the main language of the visitors, some plurals appeared in a different way than usual: for example, the words 'spectrum' and 'spectra' were singular and plural. Neither had an 's' at the end of the word. Most astronomy was about 'spectra,' a plural. He also learned that other than those tools which humans had early on, he could not duplicate them; no hexapede could.

"Most duplication won't be possible in your lifetime," said Djil. "Some hexapede will innovate photography with chemicals; you have the technology for that. You won't be able to do anything with electronic sensors. That is too advanced. The good news is that astronomers will make chemical photographs and be able to make permanent records of spectra. The bad news is that they will not be as good as those made with electronic sensors."

"You will be here for several centuries," said Djinbit. "You can make and give us good devices."

"Yes," said Djil. "Then what will we do about the other hexapedes? We can give them tools as good as humans, but they won't learn to build on their own. I think hexapedes are very like humans except they cannot import anything. Humans can't either, not over interstellar distances except for knowledge. However, they can produce all they need in their own solar system. You don't even have space travel!

"Eventually we will go away. I am worried you hexapedes won't compensate for our going, even though it won't be for a long time. You must produce! We can provide knowledge: you don't have to be like humans and make the same mistakes."

"What about hexapede scientists who can only prove old theories because they don't have the tools to do newer seeking?" asked Djinbit. "What about current scientists?"

"They are a problem," said Djil. Djinbit did not want to suffer. "I do not see a solution." Djil continued. "The next generation of your creative will have to go into history, archaeology, and mathematics. They can be sociologists who study societies. They cannot go into the 'hard sciences,' which require advanced physical technology. The current generation will have to lose, like you, Djinbit. You are not as plastic as you were. How can you stop being an astronomer? In the future, young people will choose the 'soft sciences' or mathematics."

"Astronomy is observational," said Djinbit.

"Yes," said Djil. "However, different spectra are distinguished in laboratories or by calculations. Both are based on reality. In addition to using advanced technology for observations, astronomy depends on hard sciences for understanding them.

"Geology is another example of a science requiring advanced technology; it is the discipline for studying the ground. When we are on Mars, one of the human solar system planets but not the human's birth planet and not the Earth that is referred to by the 'geo' in 'geology,' it is an important science. (When we travel to another planet, knowledge ends up in a different category than astronomy. Geology would be a discipline here, too, if we spent the time.) Besides old technologies, like hammers, which you have, successful geology requires advanced technologies. Contemporary geology requires a nanotechnology that can detect and remember as well as go through rocks; it requires machines for determining ages with a very high accuracy."

Chapter 17

Djak and Djil decided that as well as explaining everything in writing and having a few teachers like Djinbit, they should make fairly complex examples and give them to the hexapedes. That would be quicker. Most, not all, would learn more from examples rather than from writing or teaching. The first example would relate to electricity. Besides steam engines, fast moving water could produce electric power. Djak and Djil both preferred water. Copper lines could carry the electricity to where it was used. Motors, heaters, and florescent lights could transform the electricity into practical forms of energy. They did not know how the hexapedes could build efficient solid-state refrigerators and did not want to develop an industry using compressors and ammonia until they realized how useful refrigeration was for preserving food. Then they planned to create yet another industry, albeit one that compressed a poison. Batteries and rectifiers would provide for direct current.

Djak produced a non-sentient robot about the length of a hexapede. It could talk and he was in communication with it. It was obviously his since it had tentacles rather than arms. It was not too different from other hexapedes but was not so similar that it would fool anyone. Most assumed he was inside it.

The robot could enter houses, and carry on conversations. It could walk around the city and out to the dam.

It asked hexapedes whom Djak know who else should serve as organizers: "They won't be in competition with you. They will be in different businesses," he said. "I want a certain kind of person, greedy and able to understand people."

Djak mixed material, which the hexapedes produced, basically a cemented conglomerate, for a small dam on a fast moving river. Well . . . he did not do the mixing himself; he had hexapedes do it. Also, they had to transport the cement to the dam site. They could have mined and transformed both the conglomerate and the cement and mixed it all there, but Djak wanted to do more than print and persuade in the city; he wanted the city to produce. The hexapedes obtained most of the material at the site except for the cement and the generators, which they also transported. The sun lifted the water from the ocean and it came down as rain in the watershed behind the dam. Essentially, the hydroelectric generator was solar powered.

Even with dirty water going into the generators from the bottom of the lake, sediment would fill up the lake eventually. Big particles would stay. The water behind the dam did not displace many people and Djak was careful to pay them enough so they could provide themselves with more material resources than the value of the houses and land they lost to the new lake. He could not determine their loss of spiritual resources. Fortunately, he figured that most people in Glemria did not have many. They did not have much attachment to specific regions or

houses; it was not in their culture and they had not been there long enough. Children could grow up in a specific house and place, but could move as adults. Only with multiple lifetimes in the same place and house could extremely strong attachments grow and only when beliefs required it. At least, that is what Djak thought. He figured that people would be hurt in other countries but could do nothing. In so far as Glemria paid those hurt more, the country would be a good example.

His copper transmission lines, motors, heaters, and florescent lights were better than any the hexapedes could build for a long time. However, even with their low technology, the hexapedes could build adequately. Djak calculated costs based on what the hexapedes could produce: presuming high costs, that is to say, paying prices for what the hexapedes could produce at their level of technology, such as prices of land transport and the like, the project was very rewarding for a large, native organization that could bring together the financial capital.

The organization that provided the capital could be an agency of the central government. It could also be an agency of a regional or local government, a profit-seeking organization that responded to people who did not care very strongly for short term profits or one for people who did care, a non-governmental and 'not for profit' organization that was run from the top like a traditional central government, or an NGO that was different.

Various central governments competed against each other since they did not have a single, planetary government. For different reasons (yet ultimately for the same reason), hydroelectric organizations had to compete. That meant that to avoid monopoly in a single country, an organization could not be part of an agency of its central government yet could be any of the other forms.

Djak decided the model of Glatist's library was best. The people who provided the money would not care very strongly for short term profits. Senior managers would tend to select themselves for power in an authoritarian manner; the organization would be run from the top down. However, if the hexapedes were like humans, as Djak was figuring, the institution not only would last, it could transform itself. He also decided to have the transmission lines be controlled and owned by a different organization, the production of motors, heaters, and florescent lights by yet more organizations, and final sales by others.

Competition destroys what is called 'monopoly,' a single business selling goods, and 'oligopoly,' a few businesses selling goods. Competition requires many businesses. When businesses do not compete, when there is no competition among them or only pretend competition, businesses will focus on their core desire, which is to transfer resources to their equity owners. They won't invest in their business or lead governments to invest in infrastructure. Instead, they will charge higher prices and thereby prevent some customers from buying their products. Or their leaders will be frauds. In general, their aim will be to have high

prices and low volumes rather than low prices and high volumes. All this had been known to businessmen and economists for centuries — everyone knew of the dangers, particularly of monopoly and oligopoly to everyone except those who received money. They also knew how to ensure oligopolists kept prices up and did not produce what they could.

There were 'natural' monopolies and oligopolies as well as 'technical' ones. All the new businesses that Djak introduced were going to be 'technical' monopolies and oligopolies when they were introduced. Among humans, the United Kingdom and its daughter, the United States, were among the first to adopt the requisite social technologies for their cultures and therefore had early technical monopolies and oligopolies.

'Eventually,' Djak thought, 'because of competition, prices will cease to be extremely high and profits will become 'normal.' Perhaps the adjustment will take a few hexapede lifetimes. Prices will come from the intersection of supply and demand: supply will be competitive and will depend on the whole industry. At least it will where transport costs are low, along sea shores and rivers. In those places, so long as government does not interfere with internal or external tariffs and the like, there will be too many businesses for a leader to cut back on output or not invest at all, and thereby keep prices high. The leader will understand that there is too much chance for the head of a smaller business to show he could have his employees produce more and generate more profits for him. There will be too much opportunity and motive to defect. Instead, the leader of the biggest business will have to strive. Over all, demand will depend on the hexapedes' interest, such as for the electrical tools that provide light, electric lights, as they are called.'

Djak decided that additional hydroelectric generators should be produced, controlled, and owned by even more organizations. So should the production of generators and transmission lines. That meant standards for interconnection. He knew that those standards had to be protected by a government; otherwise, an organization more powerful than others in the industry had too much of a motive to defect.

Fortunately, like real estate, subsidiarity was possible. It was not necessary for a person in the central government to watch. Nor was the situation like that aboard a small ship in the ocean, beyond land-based law. Second, the army and navy would provide protection in the case of big threats. Considering the first item again: in real estate, subsidiarity, which originally meant of 'secondary importance,' now meant that a stranger protected land from more powerful thugs who could take it away; subsidiarity meant protection by government agents. The police would come if called, especially to those who supported the government and were rich. Instead of people in the central government, locals watched.

As for a standard, a committee of engineers could establish it. In this case, Djak himself would have to decide: there were too few knowledge-

able hexapedes. He would have to specify the nature of an alternating current: its mean and median frequency over a month or whatever, plus or minus an amount and whether that amount could be exceeded for a moment or not. And he would do the same with the voltages of feeders, interconnects, and end-use wires. In any case, the standard could become a contract among different organizations or its equivalent. The shareholders would watch. So would those with other stakes.

At the same time, Djak would have to make sure governments kept the various organizations competitive; there was too little subsidiarity to prevent that. The wealthier would take over the weaker, whether they had long or short term horizons. That would happen where the wealthier cared to stay wealthy. A few of the big producers — that was all that mattered — would defect and take over the smaller. They would become oligopolists or monopolists so they could readily raise prices or keep them high and thereby increase the flow of resources to themselves.

Chapter 18

Djak did not only provide an example of electricity; he introduced steam engines. Besides making sure the fuel supply was not over-consumed, was sustainable and not from a finite source, like fossil fuels, did not produce a greenhouse gas excessively, and did not produce other poisons, like human coal, Djak had to consider steam engines' implications. The kind he designed for mines and iron works would also be good for ships and boats. Ships could cross oceans; boats could go up rivers. Indeed, mobile, land-based steam engines could provide the motive power for tractors that could pull loads on reasonably good roads so long as they were not too steep. Such engines could even propel hot-air dirigibles. Or they could propel hydrogen dirigibles. The physical technology was all there.

As for the social technology: once the hexapedes had a technique for pulling together a great deal of capital to build a dam, the same technique could be used for ships and for the rest.

Bad powers would tend to take over every organization on the planet, especially each government, local or national. They would do that particularly in the empires. Djak wondered why that was. Human powers all thought they were doing good, if only for themselves and their supporters. Perhaps they did not encompass a long enough time or a large enough group. Perhaps they saw their opposition, whether domestic or foreign, as part of a zero-sum or negative situation. Perhaps those seeking governmental powers were descendants, genetic and otherwise, of old-time thugs who finally had legitimacy. Or perhaps all. It certainly would take generations to change.

Glemria was more resistant to the bad. It had more independent people. Also, the supporters of every government in Glemria, the funders and the voters, had to be persuaded. Djak knew how to do that well, but none of the hexapedes knew as much. In empires, fewer had to be persuaded, although that number included the army and the secret police. Moreover, old beliefs could wait in secret. Almost never could all be persuaded; it would be hard to persuade enough. In all instances, however, whether they were in Glemria or in the empires, enough local powers had to be persuaded.

Djak would have grimaced had he been able to; he preferred physical technologies to social technologies. Nevertheless, social technologies were important. One social technology was learning to deal with machines rather than organisms. To make the social technologies useful and a part of everyday life, he was going to have to do a huge amount of persuasion.

Still, he liked steam engines.

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Sometimes middle class people suffered disasters which made them poor. In so far as hexapedes were like humans, they would bounce back within a few years when given resources. Others were too stupid to handle all but the simplest physical technology of the time and did not think to get themselves educated. Others were very smart but viewed social as well as material goods as limited and behaved accordingly. Yet others were simply inadequate.

Regardless, another social technology that Djak felt he had to promote was income transfers. Although the technology already existed, farmers, whether peasant or independent, could not survive into old age when they did not have enough living children to take care of them.

Djak hoped that income transfers through government action would make adults more able to think long term and favor education, both for themselves and for their children. He hoped that income transfers would encourage changes within a hexapede lifetime. The upper classes already promoted some transfers but not enough.

The upper classes were almost always rich in material resources. They could bounce back after crises and would seldom want overt taxpayer help. In as much as the hexapedes were like humans throughout history, the upper classes would enjoy other kinds of tax-paid subsidy. 'Probabilistically speaking,' Djak said to himself, 'the middle and lower classes will cost although if human history is any guide, net transfers from the upper classes will be small.'

'Indirectly,' Djak thought, 'everyone richer than others will suffer as people poorer than they become more independent. Maybe,' he said to himself, 'complaints will come from those who want obsequious underlings. Without obsequious underlings, such people will suffer.'

Djak considered proposing the notion of transfer taxes to the Glemrian legislature. He knew that the economy was not as yet growing noticeably; it was still perceived as agricultural. To a very large extent it was old fashioned. Industrial production was increasing, yet almost no one saw. Most hexapedes saw growth as temporary, agricultural luck.

At that time, hardly anyone knew that the long term prognosis was for more material resources as a result of social and physical technologies. Advance would come come from the hexapedes' own changes and from Djak's. Unfortunately, few hexapedes thought that. Instead, contemporary taxes were seen as zero sum: what was forced away from one was a gain for others. Taxes were not seen as a membership fee or as benefiting all in the long term. Well . . . in Glemria they were more felt as a membership fee than elsewhere. The feeling came from a more or less joint decision on taxes rather than from a top-down decision as in the empires. Only with a long period of technological changes and increasing incomes would taxes be seen as positive sum.

Income transfer taxes could not be exported, either. They were not like some of the other laws that Djak was proposing. They did not

involve fairly direct resources like charcoal. Transfers had to be to local people, although taxes could go as payments to foreign countries. Of taxes that apparently went to pay for actions against foreigners, they mostly went to the navy at sea and the army and police on land, that is to say, to locals.

Perhaps Djak could and should delay his proposals for government-provided income transfers. After all, he had delayed mandatory education. He dared not delay too long lest opponents learn about public relations, marketing, and similar forms of advertisement. With such techniques, the opposition to government-enforced income transfers might persuade people in the hexapede legislatures. In the end, the opponents might not be able to prevent sensible actions, but they could delay them and thereby encourage more obsequiousness and, presumably, discourage change during a lifetime as an adult and produce less economic development: fewer steel mills and fewer anti-corruption efforts. That would be bad.

Djak was not sure about printed money. The hexapedes in the major empires and Glemria had had printed money for generations. However, their notes were always backed by gold and silver.

Rights to mint metallic money and print paper money went to governments. Each government tried to prevent counterfeiting. Unlike humans at the same level of technology, printing money did not become a right of governmentally-protected, yet private organizations. The governments did not even contract paper for printing from private suppliers; governments owned and controlled all.

In years past, Glemria had re-minted its metallic money so each coin had a fair amount of gold or silver in it. That was partly because of trade and partly because in Glemria taxes were voted by representatives of those who paid them and were felt to be more or less fair. Taxes were paid in the new currency. In all the other countries, taxes were quite rightly viewed as theft, since the people who paid them had nothing to do with their establishment. Besides, in those countries, the powers had little or nothing to do with trade or manufacturing; they made their incomes through direct or indirect thuggery. So people paid fewer taxes and governments made up the difference by devaluing their money and taxing with inflation.

By keeping secret the way the paper was made and by employing the best engravers, printed money could not be duplicated readily. Djak noted that in a primitive society, 'security by obscurity' succeeded since even the richest crooks, such as opposing governments, failed to pass the obscurity. As a consequence, even though they were against it, governments decided that the amount of counterfeiting was tolerable. Governments went after counterfeiting, but did not spend hugely against it. With an advanced technology, 'security by obscurity' failed because the tools were better.

The modern mantra was that anything that was made could be remade. Djak grumbled. 'It wasn't like that in the old days.' He would have to shift the belief in 'security by obscurity' among people who mostly did not care yet were powerful: shift them from believing it marked success to believing it marked failure. That was an implication of technological change that he had not thought of or conveyed. 'Well . . .' he thought, 'it's not immediate. I don't have to act on it right away. However, I should include a message about 'security through obscurity' in a new edition of *The Implications of Technological Change*.'

The technology for mining gold or silver would change because of steam engines and pumps but it would change relatively slowly. Gold or silver could serve as a constant value 'back' and their increasing cheapness would mean a slow inflation for almost every other product.

Eventually, of course, gold and silver would run out; the planet was finite. Then its price would go up and the prices of almost every other product would go down. But before that happened, there would be a huge inflation as the price of mining gold become cheaper. 'For example,' Djak thought, 'miners can spray water on certain mountains and accumulate gold.'

Waste would fill in rivers and streams. Djak went into a digression since he disliked having to persuade anyone. Without laws to prevent waste, such filling would be a kind of subsidy. A general law that prevented all kinds of damage and subsidy would be better. Unfortunately, he could not imagine any way to stop habitat loss and hoped the damaged land was not vital to any species. Habitat loss would be a kind of subsidy; it was unavoidable. However, it would stay small while hexapedes were poor. Only when enough of them were rich and their population big enough would such losses grow.

There would not be an inflation in the price of everything: technology would cause some goods to drop in price faster than gold and silver. However, the price of land would inflate. If the hexapede planet were anything like Earth, almost no new land would be made except by volcanos and the equivalent of the Dutch. Volcanic land would be unusable for lifetimes. It could be counted out. Only the hexapedes' equivalent of the Dutch would produce new land and they could not make very much. Djak had not heard of any new land. In any case, almost no new land would be made. Its price would go up on its own and as the costs and price of gold and therefore the money it backed went down. With the new technologies, the prices of gold and silver would have a changed relationship, too, since they were both mined, but differently. That difference had caused more than a generation of trouble among humans.

However, printed notes did not have to be backed by anything but promises. That was what Djak worried about immediately. He was afraid that a government, most likely an empire but it could be Glemria, would either feel itself hard pushed or misunderstand the impli-

cations. Any government — and governments had the most powerful thugs around — could simply say that printed notes were legal tender and print them.

Threats by a government would only have force within its reach. Smart recipients would get rid of dangerous money as soon as possible. But not everyone would or could. The tax on the stupid or the smart who could not avoid the money was called inflation. Printing was easier than mixing more 'base' metals with gold or silver. Naturally, governments that devalued their currencies too often or too much were distrusted; but then most were. After all, most countries' governments were made up of authoritarian rulers. The rulers and their thugs were disliked by those under them.

Since the planet was seen by its leaders in the time before the interstellar travelers came as more or less zero sum, they did not think that supply could increase or decrease in the short term except from good or bad weather or from other good or bad fortune. Indeed, it was a world of agricultural technologies with little support for seeking. Similarly, since carriages and sailing ships kept the velocity of money low and since the world was not well connected anyhow, governments or the economic systems themselves could not cause a drop in prices, a deflation. Agricultural countries would only experience deflation if there were good weather or if their governments withdrew gold, silver, or promises of them.

Good weather or other good fortune caused by nature could cause a deflation in an agricultural country; not, of course, that the farmers who suffered low prices would think them as 'good.' Under such circumstances, farmers could not pay taxes, either, not even invisible ones. They did not have the resources. So governments could not collect. Bad weather could cause inflation and people would then starve. The first who would then starve were those without connections to food producers. As a whole, governments did not like any change from what they considered 'normality.' Only the poorest, who did not pay taxes because they couldn't, liked general good fortune. They figured it might become individual.

'On the other side,' thought Djak — he was shifting to the hexapedes' way of thinking— 'in an industrial world, a little inflation is desired by the powerful since most ordinary people think in terms of fixed prices and it is easier to negotiate wages when prices are not fixed. Inflation and deflation are both price changes. Under normal circumstances, neither will be big in an industrial economy. Not only are price changes disliked, but an industrial economy can increase or decrease physical production readily.' (It was well known among humans that governments could increase or decrease the supply of printed money. Along with velocity that they could not control, changing the supply would change the price level. Printed money was mostly a virtual item, so was cheap to create or destroy.)

Chapter 19

A hexapede read about chemical photography in the material that Djak printed, realized that he had the chemicals or could make them, made a pinhole 'camera' so he did not need lenses or a fast, mechanical 'shutter,' and brought chemical photography to the planet. His first photograph was of a flower in a vase with a brick leaning against the vase. The hexapede skipped having the picture immediately look like the image and went to the more sensitive negative, positive mechanism. As for 'development' of the two pictures, the negative and the positive, he knew he had to make a room dark yet still have enough water.

The very first thing Djinbit did after he read about photography was to acquire the chemicals and make a record of a spectrum he was studying. Rather to his surprise, it was not difficult to attach the box which held the 'film' to the spectroscope. 'Film' was a word in Djinbit's language used in the context of photography. The hexapede spectroscope had been designed for a film holder by Djil or Djak as well as for eyes. Djinbit had it built according to instructions.

As for photography, Djinbit could see that he could put the chemicals on paper or even glass but for his purpose, the 'acetate-based' film was good enough — 'acetate' was not a word in Djinbit's language. The film was frozen in the past, did not show any colors, only degrees of gray, and reversed them. He did not think that was bad for astronomy: with his eyes, he saw white stars on a black background. The film recorded black stars on white. He expected stellar 'spectra' to come in pairs, one of which was standard and produced locally. From that, he could measure the unknown. Colors did not matter. The photograph recorded a portion of the spectrum more strongly, the bluer end; that part was darker in a negative. Chemical photography did not have the same response as human or hexapede eyes. That is why the interstellar travelers suggested a red light for when anyone developed film. Even though both human and hexapede kinds of eye were less sensitive to it, chemicals were even less. At the same time, Djinbit finally understood spectroscopic lines. The language was the result of a technology that started with slits. He wondered about the 'electronic sensors' that Djil spoke of; he did not see any of them. His spectroscope had no electricity at all.

Chapter 20

Glatist had plans that did not involve the army, which was becoming boring. Besides, he was somewhat famous. He had met Djak and thought he had persuaded him to come to the city. He planned to make tools with machines that Djak designed. In other words, he was going to introduce an industrial revolution, although he did not think of it that way. He wanted a more interesting and profitable life. Each individual tool would cost less than a handmade tool. The tools he made would look similar to handmade tools and do the same. He did not need much steel. He was not planning to change much except to make the tools cheaper. He did not foresee how big an effect that would have.

Glatist first obtained a contract from friends in the army, which needed tools for its logistics. After all, even if their carts and such were much more rugged than those which stuck to roads, the army trained soldiers in even rougher conditions. He then resigned and looked for financial capital. He could not find any. Banks, stock markets, and venturers did not yet exist for the likes of him, even though he was known among the people whom he visited. Glatist could only raise money in the same legal format and from similar people as his library. He got addresses from the secretary of the library and went to them throughout the town. Djak was unhappy that the secretary had given Glatist the addresses and pleased that he used his library's legal format.

Glatist was surprised at his source of capital but not worried: it would be clear that he was working for others; still he would be boss. Moreover, his organization was unlike a library that cost continually. (However, books came in and were sorted. Members took out the books; they received a reward.) He was not a head librarian. He was the leader; his organization was intended to be profit making. He expected money to come into it and to go out. Because each person invested a small amount, none would make a huge amount if he succeeded. Likewise, none would starve if he failed, not that he was planning to. He planned to succeed.

He met Bellaria while hunting for finance. She and her mother were accountants in her family's business, making tools the old-fashioned way. Her father, Teldor, had her look at Glatist's proposal. She was pretty and unmarried. She planned to manage a husband, whom she had not yet found. Her father and mother had not yet made a marriage for her. She was educated; that was her mother's doing. Both parents used the library. So did Bellaria. She learned that Glatist had left the army and was going into the same business as her family except that he would be using more machinery.

Bellaria decided that Glatist would make a good husband. Moreover, he was lovable. From her point of view that was perfect. She went after him. He was not hard to catch; he was smitten — a pretty woman and an accountant. The practical side of him valued the accountancy; the romantic, the prettiness. She also knew about making steel tools,

although with his use of Djak's machinery Glatist was not sure that would be useful knowledge. She also knew about the social aspects of business, how to fire and hire people. That Glatist valued.

Neither knew about the hidden mechanisms that enabled more of their expected children to survive hostile microorganisms, just as among humans with their histocompatibility complexes. They knew only that they were in love. They thought love was an accidental end, not a means for reproducing more genes.

Marriage was a social event, a promise that their children would be legitimate. Glatist and Bellaria's wedding took place in late summer after an appropriate time from the betrothal. That interval gave Bellaria time. She did most of the preparation. It was not early in the summer when most weddings took place.

Bellaria kept her inheritance, which she received before anyone died. It was to keep her alive until she could cope if she no longer had a husband, not that anyone expected Glatist to leave her, to be a wastrel, or to die young. Nonetheless, it was a good scheme.

Both dressed for the wedding in bright and cheerful colors. The clothing was a special three part design that Djak would have said shown low in the frequency range of visible light. Glatist liked his. (He liked Bellaria's, too, but would have liked anything she wore, just because she wore it. His was more a test.) The wedding clothing was more colorful than any he had worn in the military, even more colorful than his 'dress' uniform. His everyday civilian wear looked less cheerful, more serious, and more dutiful. It did not show dirt as much, either.

Because of potentially bad weather, the wedding took place in a large hall. Its ceiling was supported by columns three or four body lengths apart. In the high gravity and with the technology of the time, that was about as far as beams could carry the ceiling and roof at a reasonable price. The weather itself was not bad; it was a late summer day, which is to say, there was a thunderstorm in the afternoon. It was worth being under cover. Even though the higher gravity meant the atmosphere changed pressure more rapidly than on Earth and the greater escape velocity meant that the planet's air kept more elements than Earth's, the atmosphere still had thunderstorms.

More than a gross of hexapedes came. Besides the ceremony itself, people danced and ate. The ceremony itself was fairly short although as Glatist noted, it was legally as well as socially binding. An older hexapede presided at the ceremony; he represented Glemria and conducted the legal as well as social part. The whole affair was expensive but both Glatist's and Bellaria's parents paid.

For building a house, Bellaria and Glatist borrowed money from both parents and friends; they did not borrow from any strangers since they felt, as did thousands before them, that parents and friends would give them better terms and be nicer during troubles. They built a six room house: main room, kitchen, store room, bedroom, bathroom, and

'future room' for a child or children after he, she, or they grew enough so Bellaria did not have to pay too much attention. (Unlike many human males, Glatist would not pay much attention when they were very young.) The only difference from standard houses — and in any event, the house was part of a sizable minority — was that it was all on one floor, the ground floor. Glatist knew he would grow old eventually and would have a hard time going up steps. He was willing to borrow more to pay for the cost of the extra foundation. He did not think he was going to pay for building another house. Bellaria did not care.

The house was L-shaped and had no halls. It did not have a guest room nor did it have any way for children to run in circles through several rooms or halls. Rooms had four sides rather than six. The bathroom was in one wing between Bellaria and Glatist's bedroom and the 'future room.'

The bathroom had a large tub although Bellaria and Glatist had to bring hot water from the kitchen which along with the store room was in the other wing. The bathroom was above a well so they had cold water. The toilet was along a wall with its own window. It was in an inner room that had walls that were not load-bearing; it was not counted as another room.

The toilet had to be washed after every use. The water also carried the waste. It went outside to a slightly buried trench that Djak thought was too close to the well but did not seem to hurt the hexapedes. The trench was a traditional distance away from the nearest well and Djak hoped that was far enough. The kitchen stood above another well, so people could also pump. Hand pumps cheap enough for Bellaria and Glatist had come a few lifetimes before even though successful pumps had long been invented.

Only the main room at the crook of the 'L' had a ceiling two stories high; the rest had normal ceilings. The house had six outside doors, four of which had strings coming through the door that could lift the cross bar that kept it shut. Mostly the strings were pulled in and a plug, also on a string, inserted into the hole from the inside. The only locks were in doors for the kitchen and the main entrance, at the inside crook of the 'L.' Both had similar keys and were carried by Glatist and Bellaria. The two keys and the spare were big. A graveled path came to the main entrance and the kitchen.

The two slept on a fancy rug with another that covered them. No one had the money to pay for tiles with chimneys that went though the floor before going up. Instead floor tiles stood on a fairly thick layer of sand. Each room had its own fireplace, which served for heat. Djak made sure that they had proper throats and dampers; and that they and the other built-ins, particularly the water pumps and the locks, could be changed with the new technology he had already described, but hexapedes had not yet produced.

Parts of the walls could be knocked out for electrical wiring, although none existed yet. Those parts were low down. Most holes would be between rooms; one would go to the outside. When electricity finally came, the wires would be pushed through conduits that would attach to the lathes on which plaster was coated. Not only did the plaster reflect infrared, which gave the rooms a comfortable feel, and was an off-colored white, so the rooms were lighter, but it and the lathes that supported it covered an airspace that insulated it from the stone that made the outside of the wall.

Djak also insisted that chimneys have connections to them so that when heating stoves were built, they could be installed without being placed in any fireplace. Glatist agreed immediately; Bellaria after a little time. She wondered whether the hexapedes would produce stoves and then decided they would; other existing houses would put them in place of fireplaces.

Since governments did not tax windows, as they had among humans at one time and place, the hexapedes had them. Light came in from at least two sides of each room, except for the toilet room. Windows were better and less expensive than lamps, better and much less expensive than candles. The raised roof of the main room had windows along its four sides. Ground floor windows had iron bars dividing them to keep out thieves.

Hexapedes had cups, bowls, and plates just like humans. Eating and preparation tables were half the height of regular tables so the hexapedes could look down at their food. Both the kitchen and the main room had eating and regular tables but in different proportions. The kitchen had more eating and preparation tables. The main room had more regular tables.

Glatist succeeded in raising financial capital. After Bellaria and Glatist spent it by constructing machinery in a building they rented and started their business, they made more money selling tools than either expected. They bought the building they rented as well as land around it. The land and building were next to a navigable river, which meant cheap transport. The machines were powered by Djak-designed steam engines.

Bellaria knew that her incremental costs were low. Her fixed costs were higher than in the past, but when she made enough tools her average costs were low. She knew that the average price had to pay for everything, including fixed costs. Djak gave her and Glatist suggestions for selling. She thought they were good, as she told Glatist. He agreed and followed them.

Even though her fixed costs were high, overall costs were low because of the lowness of her incremental costs. Mostly it was the new technology but partly it was because she could sell in Glemria without hindrance on any river with low transportation costs, which enabled her to have more sales. Djak called the incremental costs ‘marginal,’ saying

that a human economist had been concerned with the lower productivity of 'marginal fields' and 'marginal' had become the term among human economists. He said that a balanced economy equated all the marginal costs since investors so long as they were profit seeking, that is to say, greedy, tried to make as much as possible; otherwise they would make less. He had forgot that people could and would put up hindrances. They did that for what they thought of as good reasons, such as disagreement over what constituted happiness to them.

Bellaria felt that her machine-produced tools were not marginal in any sense. They were better. She could see that a static economy could be balanced, with every business having 'normal' profits and the lower productivity on the margins limiting capital investment. Deferred return, which investors experienced, had to equal or exceed the value in the present. However, she did not intend to have just normal profits. She wanted high profits. In addition, the economy was not balanced. It would not be for several lifetimes at the very least. Djak's model might hold for the agricultural past and the planet-impacting future but it did not explain the present.

Glatist paid himself more and gave most of it to Bellaria. As for the rest, she put most of 'his' profits back into the business. Glatist hired experts to construct even more machinery. He built buildings. He hired more salespeople, too. They persuaded even more people to buy. Lower prices made a big difference. The business sold vast numbers. In addition, its tools were better than most. Heads did not fly off hammers, not as frequently as with those that were handmade as cheaply as could be. Heads stayed on more often when hammers were put together by machines. The business sold tools everywhere, not only to the army.

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Bellaria's father, Teldor, also manufactured tools. He had been a little more successful than he had expected. Tools were useful and he was good. However, Teldor had been in a competitive industry. There were no 'just prices' or any other restrictions. Before Djak and Glatist, any group with the right knowledge and a little capital could have entered the industry. None had to be thugs, whether for the government or otherwise.

Not even the empires had instituted monopolies or oligopolies on tools. To do that would take a physical technology, Djak's machinery, which cost a large amount, not a social technology. No one thought of the library as presenting a social technology, although a vast amount of capital was necessary to pay for Djak's machinery and the subscriber library model did present such a social technology.

Djak was of two minds. On the one side, in Glemria in general and in the empires in this particular industry, no one dared for good or

bad reasons to restrict output, to create a guild system or keep private monopolies or oligopolies or massive state-owned industries. On the other side, a modern, individual business that produced real rather than virtual goods had to be big enough to bring down its fixed costs. Such a modern business would be bigger than its hand-producing predecessor and, while it was new, a technical monopoly.

If the hexapedes were like humans, after an initial period, the people in private and public monopolies would try to continue as they were, keep their jobs, and from an outside point of view, become more stupid. For an economy to do better, it had to have transparency and competition. Djak could have said that the powerful had been and were still unhappy since with transparency they could not hide stupidities. However, they did not want to lose either. They wanted and had wanted to win. Consequently, they had had and still had to accept transparency as the lesser evil. To cause it, they had to accept competition. At least, some of them had to.

The powerful did not like competition; it effected them. They could not be safe and make huge profits. They did not like stupidity, either. Lack of competition implied stupidity eventually. Most people would try to keep their jobs and keep as they were. That meant the army, a public monopoly, would act more stupidly over time. That was why Nerrig was commander. However, people like Glatist were picked properly. They could improve the organization. The powerful would see the two as a trade.

On the next hand, Djak decided that principals had reduced the scope of agents' decisions, at least in controlled monopolies. Every action must have become more bureaucratic. The powerful would have insisted on two or more agents in the same place instead of one. Two agents could watch each other. Competition reduced costs, but doubling (or more) the size of the work force increased them. All in all, he expected that the direct costs had increased and indirect costs had decreased.

Djak kept considering. The creatures in power in Glemria had to be more honest themselves. It is impossible to have corruption and transparency at the same time. (It must have happened some time ago, before cannon.) Those who succeeded were capable, but the nature of the capability changed. That change must have caused conniptions among the corruptly powerful. Their capability was not rewarded. That is to say, their capability for corruption was not rewarded.

The competition from machine-made tools squeezed Teldor. He produced handmade tools. His business grew smaller. To survive, he had to learn new ways even though he had contacts. They saw cheapness and quality. Teldor thought of his employees as 'part of the family' and did not want to let them go. But he did. They weren't quite as close as his wife. He did not fire all his employees since some of his customers still wanted handmade tools. But most customers were ori-

ented towards price and quality. Machine-made tools had lower prices and higher quality.

The workers Teldor fired were skilled and could shift to Glatist and Bellaria. They were experts. With almost no training even though they had done mostly repetitious and different work before, they could build the machinery that Djak designed. Then they operated it. Teldor himself was past middle age and did not want to struggle as much as when he was young. At the same time, he did not want to become dependent on Glatist and Bellaria, not until he was decrepit.

Bellaria's mother was a kind of employee but also the wife of the boss. She could adapt and did. She was an accountant just the same as Bellaria. She understood what machinery did. To be even cheaper, she reckoned that the price of hard steel would have to come down.

To continue, Teldor had to make big changes. He had to raise more capital than he ever imagined in a format he had never considered. Not even Glatist could loan him enough.

He knew many people in the city and made the rounds. He did not expect and did not look for banks and stock markets. Since he had experience, he got money from many who had supported the library although he found them in a different way than Glatist. Some people were happy they had another investment. Others, after they paid for their library, for electric organizations, and for Glatist's company did not have enough. Fortunately for Teldor, he also gathered money from contacts who were not involved with the library or other ways of investing money.

After collecting money, Teldor hired more men than he still employed to build machinery. He kept his handmade, 'custom' tools as well. Then he thought of being a conduit for other businessmen trying to raise money. He consulted Djak, who told him, "You will have to move to the capital. That is the best place. I know you won't have contacts there but you will succeed with printed material and sales people. You will have to print many different items, make a lot of calls, and determine which ideas will bring the few people who want to invest. That is how it goes. Your sales people will explain to those who prefer listening rather than reading. You will have to hire people.

"It will be a matter of probabilities, but you will not be gambling or fighting. Any kind of selling is a matter of probabilities. Fighting and gambling only bring in short term profits to those who succeed. Well . . . a casino can last a long time; it gains a portion of each bet. It's like any other business in that it takes a portion of what it sells, but what it sells is disagreeable. Keep your tool business. Hire a good manager for it.

"As for your being a conduit: not many will want to invest, but the number in the capital will be more than here and you will be successful. You do not have to fear failure, not in your lifetime. You do have to fear slowdowns, but not as much. The demand is going to continue,

the demand for cheap tools as well as for gauges, which you should also fund. Indeed, you should fund just about anything new. You'll suffer slow periods. Nevertheless in the long run, demand is going to continue."

At first, Teldor and Bellaria ran a duopoly; they were the only two sellers of relatively cheap machine-made tools. Glatist thought he ran the business; so did Bellaria. She specified prices. Teldor and Bellaria could agree on prices that were lower than their hand-made competitors but higher than they needed. Bellaria could keep track of even more sellers, an oligopoly. Only when the number grew too big would there be competition. By then, she would be long dead. She expected large numbers of machine-made tool businesses only after a good many lifetimes.

Prime movers who invented, or in her case with Djak's designs, first movers, had an advantage. Their business learning was ahead of others. They learned the team work necessary for both producing and selling. Moreover, their businesses had large profits. Their incremental costs were low. Although their prices were lower than anything handmade, they were still high. Even with their payments for fixed costs, profits were higher than others'. They sold a huge number of tools.

Potential competitors would never grow within Bellaria's lifetime, only friendly oligopolists. She had to permit them. They were a kind of competition, but not bad. She did not want anyone else in the business; she wanted a monopoly or at most a duopoly with her father, but recognized that others would see her huge profits. In addition, with monopoly or duopoly, her people would become more complaisant. They would in an oligopoly, too, but less so. Without others, her people, maybe she herself, would appear and even become stupid, which is to say that others should enter the business. Because of profits, they would.

Chapter 21

The tool business grew fast and big. Bellaria was pleased. She hired a cook who was also a cleaner and a fellow who could do heavy work and work outside. They lived near by. She had more time for accounts and liked that.

Using her additional time as an accountant and looking over her past records, she saw that one of her wood suppliers was increasing his prices to her. The wood was for burning to provide energy which they used in making tools. She used the term 'energy' now even though it come from the humans. It was more general than the term 'fire' even though they burned the wood and the term 'fire' would have been good enough. Metal was heated by burning wood and then shaped mechanically. So was wood. Machines were powered by or used steam; the water for it was heated by burning wood. Other wood, for handles and such, was bought from different suppliers.

Gildar sold to Bellaria wood that was burned. When she commented, he told her that new shoots of wood were not as strong and big as the old. They appeared quickly; much faster than anything he planned to cut. He watched them anyhow since they were his future. The same problem appeared with plants that farmers sold as food to cities but not when they ate plants themselves. "Food was better in the old days," he said. The comment turned out to be irrelevant.

"I'll ask Djak," said Bellaria.

"It shouldn't be worse," said Djak at first. Then he said, "No, on thinking more about it, I was wrong. You said new shoots were weaker and smaller. They were on the stumps of the wood sold to you or else they came from farmer's plants, right?"

"Yes."

"I did not expect it to happen. My mistake. We are removing nutrients or perhaps micronutrients that cannot be replaced with water and air. At least, that was the case on Earth. Your wood supplier, Gildar, can check whether it is true here by spreading your ashes on some of his stumps. It might not matter that everything is burned. If that works, you can sell ashes to Gildar. You will receive a little from him. It won't be enough to pay for your wood, but it might be enough to lower your costs to what they were. I am not sure what we will do if you cannot burn the wood."

Fortunately, the ashes were sufficient. No one had to mine for replacements or grow them. For farmers, hexapede fecal material succeeded. The hexapedes in Glemria associated disease with feces. They would not go near it. In other cultures, various hexapedes handled it. Djak decided to show composting with fecal material. Hexapedes already knew about composting but did not know about the combination with their fecal material. Composting would make the feces more harmless and less smelly. Composting would also add organic matter

and would produce an income for those organizations that sold the compost. He did not know whether feces themselves should have a price before it went to a sewage plant but after it came on to the public way. Cities had to have sewers since the houses were too close together for trenches or pits; sewers meant the feces could go into rivers or they could go into compost. Everywhere, sewage cost; in cities, especially so. The hexapedes were going to need two systems so they did not make the same mistake as humans who inadvertently put poisons in their fertilizer and could not sell it. The fertilizer was going to cost the farmers but not so much as to put them out of business.

Djak decided that fertilizer could be like mandatory education: 'Why should anyone pay directly?' he asked himself. Then he thought more. Fertilizer would not effect a second tree when it was spread on a first. And results would be soon. Those were the answers. Only goods that could be duplicated readily, like knowledge, should be free. That is why farmers should pay for fertilizer. It would only be a few years before it became apparent that hexapede fecal-material-based fertilizer produced bigger and better crops for those who used it. The organizations that made fertilizer could pay for fecal material, too. It could not be much since the material was just one of their costs.

Djak wondered what other elements should be added to the fertilizer. Among humans, potassium, phosphorus, and nitrogen helped. With microbes, plants could obtain nitrogen from the air. However, potassium and phosphorus had to be dug, moved, and not washed way. Depending on location, there were other necessities, too, molecules he could produce and conglomerations he could not, since his duplicators made everything very cold. He realized that he did not know what would help hexapedes.

Finding what helped them could be the jobs of hexapede scientists and engineers: the first group for seeking and proving, the second for making fertilizer cheaper, which meant devising less expensive mines, transport, and selling strategies, as well as less expensive ways to produce the fertilizer. Djak wondered who among the hexapedes would innovate? A few would, but how many? Eventually there would be a tipping point, but how soon would it be? The social technologies became more and more important.

Chapter 22

Djak thought about religion. He was curious about everything and even though he was a computer, he was a human based one, which is to say, he had a large number of human characteristics. He considered tribes who believed in a strong and single being who was always there; those who believed would certainly be more honest among themselves, fight against strangers, and after they were defeated, treat them more or less honestly. That would help such tribes and explain why they grew; after all, while a few converted voluntarily, most had belonged to tribes which either did not believe in honesty towards those outside the clan or were conquered by those who did. That was why most of the agricultural-technology peoples had such a belief or one derived from it. That would handle the largest minority, those who preferred a scheme that involved greater than and lesser than. What about the next largest group, those who preferred the distinction between nothing and something or sharing and equality?

'The distinctions between something and nothing,' Djak thought, 'or sharing and equality are all the same. After all, if you have something rather than nothing, and everyone is close to you, you would want to share. Every one will be equal. So successful religions will advocate sharing as well as conquest, at least after they have gained enough power to conquer.

'As for those who prefer greater than and lesser than, someone greater than you will have people whose names you do not know, that is to say, administer a group larger than a simple meeting. Then, that person will distribute benefits and punishments to people lesser than him or delegate the distribution.'

What about the rest, who made up a fifth or less of the total? Those who preferred one operation would see visions of caring or whatnot or hear voices and those who preferred two operations would restrict themselves mostly to one item. The visions, voices, and items would be defined by the culture of the people's childhood and would mostly keep the culture stable. If they changed matters and succeeded, they could introduce deep changes. Only a few would try to invent something new to the culture and only in a few cases would they succeed. Deep changes not only had to be at the right time for the social and physical technology, but also preferred by the vast majority of people, which is to say, by those who preferred sharing and authority. Djak thought the numbers of those who succeeded with deep changes would be enough.

He continued to think. 'It will take many years while whoever succeeds with deep changes is still alive and many more after that. The organization (the movement would have to be organized) will have messengers and lesser followers. Even so, the organization will not necessarily be universal, although many will try. Only a very widespread technology will enable changes to be planetary and then only an organized technology can go into every nook and cranny on the planet,

which is big even if it can be covered by a thumb if you are far enough away. Only a sufficiently advanced social and physical technology can be widespread and only one with duplicators or constructors can go into every nook and cranny. The hexapedes will not have that ability for lifetimes. On the other side, if human history is any guide, many older religions tend to discourage seeking; they dislike science. That makes sense since they are supported by local powers, who like cringing. Besides they thought differently; their culture does not support economic development. They figure that human engineering and science lead to misery for many people on the planet.'

Chapter 23

Ditertra marched up to the observatory. She wanted to become an astronomer. Her parents had helped her be independent.

Djinbit heard her knocking, went to the door. At first, he thought she was a salesperson trying to convince him wrongly. He did not notice her clothes at all. He intended to put her off by asking what would be the period of a gravitating object three times as far away from the sun as his and her planet.

She answered his question. After thinking for a moment, she said, "More than five years; perhaps 5.2 years. I don't know the square root of twenty-seven. The square root of twenty-five is five."

"How did you come by that?" asked Djinbit. He was surprised.

"I figured that for a mental approximation of a body in an ellipse I should use the rule that 'the square of the period is proportional to the cube of the semimajor axis' and ignore the effects of every other source of gravity besides the sun. The cube of three is twenty-seven. I have to take its square root but I am not sure of that; all I know is that the square of five is twenty-five."

"5.2 is close enough. What else do you know?"

"Besides knowing many stars, I can calculate the planets' and their satellites' locations more accurately on paper using proper mathematics," said Ditertra. "I want to become an astronomer."

"Let's see how good you are recording time," said Djinbit. "Maybe I will employ and teach you, although with the alien visitors, there is less need."

"What do you mean 'the alien visitors?' "

"The big bird that flew over the city turned out to contain two aliens with a more advanced technology. He wasn't a bird," said Djinbit. "Nothing we will do for several lifetimes will be meaningful."

"I didn't know that," said Ditertra; "only that a bird flew over the city. Neither my parents nor I live there, so all we heard is distant gossip. So my recording," she said, "will be meaningless." She sighed. "Times of transit, presumably?"

"Yes, times of transit. Then, if you are good at that, we can both look through and sketch Fulg in my reflecting telescope. They have a more advanced technology and astronomy has gained. A creature showed me what she can do. Djil came out of the big bird, which turned out to be a ship." Djinbit suddenly realized that only Djak was known and that the reflecting telescope was supposedly changed by a robot. But he could name it. Ditertra would see either the robot or Djil herself. They looked identical and so long as one remained hidden while the other appeared, it would not matter. He did not remember having spoken of two aliens.

Ditertra was thinking about something else. "You have a reflecting telescope? I have read, but never seen or looked through one."

"As far as I know, I built the first one. That is why I refer to it in the singular. Now I have two, since Djil built a 'Newtonian,' as she calls it. She increased the size of the main mirror of mine, too. I suppose there is almost nothing left that I actually built. In any event, I built the first reflecting telescope on this planet. A couple of people wrote about reflecting telescopes, but none constructed any before me. You had to have read specialized books to know about them. How good are you at recording times?"

"I read well but have no practical experience in astronomy. Do you really want me to sketch the planet?"

"Yes," said Djinbit, "if you do well recording. In any case, we should let Fulg rise fairly high above the horizon. That makes more of a difference, now. The planet really does look better. You'll see." He frowned for a moment. "I expect."

Ditertra was good at recording transit times; she was good at sketching, too. She liked his planetary reflecting telescope and wanted to look through the 'Newtonian.' She was very careful when she said the word; it was not any she had heard before. As far as Djinbit could hear, it sounded right. At that time, neither knew the type was named after a human.

Ditertra looked at several nebulae and clusters. Djinbit told her to look at the nebulae with a high power. "Some," he said echoing Djil, "are clouds of gas; others are distant galaxies. We are in a spiral galaxy, like those you see." Djinbit did not know what a galaxy was, other than he could see them and each according to Djil had a huge number of stars.

"I can draw the nebulae, most of them," she said, "but not the clusters. Clusters have too many stars."

"Can you make approximate sketches that are accurate for what you have recorded?" Djinbit asked.

"Yes," said Ditertra. "I can do that."

He had her calculate the position of Fulg for a night during the next month as seen from his location; it was in agreement with his calculation. He hired her. She rented a square cottage nearby. It had only one room, but she did not mind; except for sleep, she was hardly ever in it.

Djinbit told her about Djil the next night. Ditertra had forgotten that he had mentioned Djil; she only knew about Djak. However, when Djinbit spoke of Djil and she realized Djil was close, she said, "Let me meet it. I need to learn from anyone who knows more than even you! Besides, I'll be careful."

"She's a 'she' not an 'it,'" said Djinbit, "and there is a speaking but non-sapient robot that looks exactly like her that Djak gave me. Djil

is sapient. So there are two that look alike, one sapient, the other non-sapient. Both carry screens, which are non-sapient robots that speak. We are supposed to pretend to others that Djil does not exist. That is to keep her existence secret. She does not want the bother that Djak has. Also, Djak gives the impression that 'radio' communications are limited in distance and amount, though they are not. That gives him an excuse to visit physically."

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Ditertra met Djil, and then both Djinbit and Ditertra began to read the material on astronomy that Djil and Djak had printed. Over time, they learned the theories that human astronomers held at different periods. Djinbit preferred reading. He could read more quickly than he could talk or listen. Both Ditertra and Djil let him. Ditertra was exactly the same.

Indeed, over several years, the two studied everything the humans had about astronomy. Fortunately, the material had been well written initially. Moreover, it was well translated. The words started simple, grew more complex, and the material was organized in a manner that suited hexapedes. The training in human academic writing came later and was conscious.

Djinbit was a little slower than he had been when first a student, but he was not that bad. He learned early on about the types of star. In addition, he learned about galaxies and types of galaxy. Ditertra absorbed everything. It took them a long time. The material on astronomy included much from and after the beginning of electronics as well as what went before. Like bioengineering, there was so much change, it had to be described.

After considerable study, Djinbit went to Djil. He remembered vividly that he had said once that he would suffer, that they were not many like him. Unfortunately, he had seen what the humans had discovered. Moreover, he did not like suffering. He wanted to be on the 'leading edge.' He liked that metaphor. He figured it had to be common among humans as well as hexapedes since the metaphor was based on very old technology.

He explained to Djil. He wanted to be a seeker in communication with Earth. Because of the side benefits of their technology, in particular, because of having more material and a belief system that promoted scientists, the humans had more astronomers. They were more advanced. The speed of light delay in crossing interstellar space would delay messages to the observatory and any reports he or Ditertra made. Radio would take a quarter of the time Djak and Djil had traveled. Nevertheless, Djinbit figured that he and Ditertra could chose a topic

no one else researched. Then no human astronomer would care that they received information more than a generation late.

Djil considered. Djinbit was an excellent astronomer. So was Ditertra. Djil had asked questions as the two astronomers studied and found both of them good. In any event, Djil did not care for astronomy as much, although she could judge people. Even though she could remember everything, could think well, and was interested in it, dedication to astronomy was important. Remembering, thinking, and interest were necessary but not sufficient conditions. Djil knew she did not have the same dedication as Djinbit or Ditertra.

Djil wanted to remain consistent, but she kept remembering Emerson, who had written that "A foolish consistency is the hobgoblin of little minds . . . " She did not want to be a 'little mind.' Besides, the two were careful.

So Djil said to Djinbit, "I will be inconsistent. You will get human sensors and equipment, but no one else will. To prevent jealousy, you will have to keep the material objects and your work a secret from other hexapedes. Your telescopes will be in space. You must have several on account of the different frequencies each design can receive. Being in space will mean your people will not discover them for a long time. We can hide them behind Kuiper Belt objects when other telescopes become good enough to see them. In any case, that won't be during your or Ditertra's lifetime.

"As for perceiving what telescopes see, I will provide both of you with devices; we call them 'spectacles.'" (For 'spectacle,' she used the derivation of a word in Djinbit's language; he understood it, even though he did not need anything for his eyes.) "However, you will have to hide your 'spectacles' when other hexapedes come. Also, I will provide recorders and a transmitter. Those will already be hidden. Your antenna will be the biggest item you wear and it does not have to be all that big. It will be disguised." She grinned.

"Both of you will be able to communicate with me by radio. You will be able to see and hear what I see and hear. You will still have to speak both to me and for your reports. You will not have a thoughts-to-text converter nor will I go into your body. You will have to be alone when you speak out loud or only with each other. That will not be hard."

Chapter 24

Djil gave Ditertra and Djinbit gamma ray, X-ray, ultraviolet, visible, infrared, and radio observatories, four in all. Well constructed optics meant that ultraviolet, visible, and infrared could be one telescope; the same with radio. Each telescope required a different receiving technology. All in all, they covered octaves of electromagnetic frequency.

Both Djinbit and Ditertra spent time at first viewing what looked to them like real images with their spectacles rather than looking at spectra and analyzes. Both hexapedes were amazed at what they could see with 'photon collectors' and with electronics that did not waste any of the photons. They looked at parts of distant nebulae and at distant galaxies, but not ultimately distant galaxies. Every input to them except the visible was false colored. As in the visible range, blue indicated higher frequencies. Although the higher frequencies had more energetic photons, red could be chosen for their displays, even in the visible range. Hexapedes' fire, like human fire, was mostly in the red range; bluer colors were 'cool.' Consequently, many hexapedes thought of higher energies as red colored.

However, both Ditertra and Djinbit understood and insisted that blue always show higher energies, even if dimmer. The amount of light, its amplitude, would show amount. Although much of their learning was theoretical, they, like other astronomers, paid great attention to colors. Later they would see a graph of frequency and the amount of light at each frequency, with error bars also indicated. A graph would not show many colors except for the background as seen though the spectacles. If drawn on paper, the background would be the unmarked paper and only one color of ink would be needed.

Djil was not surprised that Ditertra and Djinbit looked first at what they thought of as images rather than at spectra. When compared to their level of technology, the size and other advances in telescope making were huge. Seeing images was a matter of wonder. The images looked more or less real. Books printed by hexapedes did not have multiple-color pictures, although they had many single-color pictures and Ditertra and Djinbit knew what they were seeing. Finally the two went to work and looked at spectra. They did not need the kind of resolution provided by the interferometry of separated telescopes; they did use all their different kinds of telescope.

Chapter 25

In Glemria, one local power, Grindel, saw only that Djak suggested mandatory education of youngsters. He hated that, even if implementation was to be a generation away. Since they would be in school, the young of his tenants would not be able to work for him. He expected his taxes to rise. He did not perceive the physical technologies also being promoted. Indeed, he could see no changes that could benefit him. Moreover, he was violent and could afford to hire an assassin. Consequently, he attempted to murder Djak. Grindel was the only one of the local powers to favor murder. Most were not so violent even when they saw no changes that could benefit them; they competed more or less peacefully by persuading otherwise independent farmers to hurt themselves and help the local powers.

The assassin, Mankof, thought that Djak was a big bird. Mankof did not know about 'mandatory education,' only that Djak should be killed. The fellow thought he could do that. During the night, he climbed over the wall into the courtyard surrounding the station and tried to sneak up on Djak. The assassin did not know about Djak's advanced technology and was found by a non-sapient mind that Djak had delegated to watch in infrared and to listen. The non-sapient mind notified Djak. He decided to speak when the assassin had finished climbing over the wall but was still close to it. At that point, Djak lit Mankof with a visible spotlight, temporarily blinding him and making him visible to every one else. "I see you are carrying a long knife in an army courtyard. Yes, you may carry a knife outside the courtyard; you may even carry it in here so long as you declare it to the guard at the door. Have you done that?" Djak knew that the assassin had not and left him to the guards, who rushed to him and disarmed him. Before he was taken away, Djak said, "I have advanced technology. I heard you climb up the wall and watched you climb down in invisible light."

"I thought you were a big bird."

"No, I am not. You will not be imprisoned very long when the only charges against you are entering an army courtyard without reporting to the guard and carrying an unrecorded knife in it. But you will be imprisoned. Many guards have seen you. Even if the judge were corrupt, you would have to be convicted. Conviction does not mean you would be imprisoned, but you will be. You will be imprisoned. Fortunately, few of the army, the navy, the police, or the judges are corrupt. I will not ask what you are doing here or who sent you. I presume you were going to try to assassinate me, but I don't know for sure and I am not going to ask. Just remember, nothing you could do would hurt me, not even burial. I would just dig myself out. When I came here first, I would have taken longer but now I can dig myself out quickly."

Djak did not say that he could produce diggers or that he had absorbed a good deal of energy from the sun and stored it in a battery. As for the diggers, he let 'advanced technology' cover them. The phrase

was in the hexapedes' language. As for 'energy:' he did not speak the word. Only a few understood it as more general and abstract than 'fire,' which he did not say, either. For most, the word 'energy' was foreign and incomprehensible; nor did Djak want to mislead any with the word 'fire,' which all knew.

Djak could be killed, although with frequent backups, he did not concern himself with death, unlike many humans or current hexapedes. So long as he did not care about holes in his memories, he could live a very long time. With backups no technology was fatal. The only reasonably new technology that could hurt him among the hexapedes was gunpowder for blowing him apart. An older technology would have him pushed over a cliff or into a big and deep pit. Either could destroy his 'brain.' Until it was rebuilt and the backup loaded, he would perceive and do nothing. He would be 'dead.' Rebuilding his brain and the rest of him and loading his backup would have to take place in the asteroid belt or be done on the planet by Djil. As for gunpowder: he doubted they could get enough close to himself quickly, not even with shells shot at him. He did not plan to fall into a pit or walk over a cliff, either.

Chapter 26

Ditertra and Djinbit argued. Djinbit sometimes wondered why it hurt so much. His other disagreements did not, not even his arguments with Sligtor.

Sligtor was another astronomer. He had his own observatory, was a little older than Djinbit, and was equally as smart as him. He was a good astronomer.

He came unexpectedly to Djinbit from his own observatory and asked, "How are your new telescopes?" Djinbit was so surprised he jerked a little. Sligtor said, "I won't tell anyone; what have you got?"

Djil intervened. She saw that Djinbit was confused by Sligtor and a poor liar. She said, "I'll make you telescopes so long as you keep them secret." Sligtor was surprised; he believed that Djak was the only interstellar visitor and knew nothing about Djil's ability to speak whether close by or at a distance through remote speakers. Since Sligtor had never heard Djil, he could not tell the two apart by sound, although he thought the voice he heard was more like that of a child. Sligtor could think on his feet quickly and said, "I keep secrets."

Djil introduced herself — Sligtor was astounded that there were two interstellar travelers, but kept his expression clear — and she said to him and to Djinbit that she would build telescopes for Sligtor, too, that they could compete against each other, but that their true audience was the astronomers of Earth. It would take six dozen years for a round trip — for a response to come to them even though they used the fastest known means of communication.

The arguments with Ditertra were over the interpretation of their astronomical data. (Only after first 'discussing' observations with Ditertra did Djinbit talk with Sligtor.) Photographs were blurry, whether they were radio, infrared, visible, ultraviolet, X-ray, or gamma ray images. More importantly, spectra were vague. Since they were working at the leading edge, everything was blurry or vague. Only settled notions were sharp and clear. The two could take good pictures or spectra of those; that is how they calibrated their tools. But sending them was not worth the nearly three dozen years it took for radio to travel just one way to Earth.

Djinbit's other disagreements did not pain him the way his with Ditertra did. He could not tell other astronomers besides Sligtor of his equipment, so he had to pretend not to do much, which was reasonable; other astronomers did even less. On the other side, Djinbit remembered the time before the interstellar travelers came. They had argued. For them, their tools were on the leading edge. Djinbit reflected. 'It's not that I don't have another person with whom to argue. It is Ditertra herself. She is a good person. She is often right, too!'

Ditertra did not want to fight so strongly with Djinbit. Yet when he made a wrong interpretation, she had to disagree. She thought of

herself as the youngest astronomical seeker on Tellos able to do anything worth while. For some reason, disagreements with Djinbit were much worse than she expected.

Neither Djinbit nor Ditertra would hear from Earth for dozens of years. The transmissions had to go both ways. Consequently, they had to think of everything before sending anything.

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One afternoon, Djinbit asked Ditertra, "Do you think there are more charlatans today than there were before our industrial revolution, my dear?" Ditertra noticed the affectionate ending phrase; Djinbit was not aware that he had said it.

"I was accosted today by a fellow who was trying to sell me an oil that would enable me to live forever," Djinbit said. "I managed to get a small sample of the liquid; I suspect the fellow thought he was going to hook me. I had Djil analyze it instead. She said the oil contained four substances; she recognized all of them. She said that one was useful, an analgesic, one stimulated people and was a muscle relaxant, that was also useful, one stimulated people and was addictive, not useful, and one was a harmless carrier. She said that already apothecaries grind a particular plant to produce pills that contain the pain killer with an accuracy of a twelfth or so. She says you can get the muscle relaxant from a beverage we all drink. The third item is not useful to us although it would produce income for the seller. The oil is not an immortality drug."

"Without an inquisitive mind and without the convenient analyzes that Djil provides, people will not discover what a liquid contains. They will have to fall back on general claims, such as, 'If it is too good to be true, it is too much,' " said Ditertra.

"I agree," said Djinbit.

Ditertra did not answer his question about the number of charlatans.

Chapter 27

The price of land rose because investors saw that its quantity was not increasing but the population was, no matter that parts of the world were still underpopulated. Price depended on location. Then other investors saw that land and houses were a good investment because their prices were rising.

Bellaria was one of those. She saw the price of land and houses go up and invested a good portion of her bridal money. Then she got scared and withdrew. Rents, although rising, were not as high a part of the total value of land and houses as they once were. The rise was weird.

Bellaria watched the price continue to rise — she did not make any profit from it — and almost invested again when the price dropped suddenly. Large numbers of investors lost a good portion of their capital. Those who had borrowed lost more. Bellaria was not among them and was thankful.

Then money could not be found. No one could borrow. Business slowed, especially new business. For Bellaria, current profits in the tool-making business vanished. At first, she did not see any connection, just that her current profits were going away. She, that is to say, the business, was selling less. Then she realized that most of 'her' sales were to new companies; old companies already had tools and only needed replacements for lost or broken tools. When she realized that she was not selling as much, her first thought was to fire those who were not doing anything. However, she did not want to fire those whom she thought of as her employees (they were Glatist's, too) since she knew they could not get jobs.

How would she deal with this? She could afford a few months of paying people to do nothing but she could not afford it forever. She had no idea of how long bad conditions were going to last.

Djak came to her rescue. Bellaria visited him in his courtyard — he had not made his 'official' announcement, which was later. He extracted gold from ore. He loaned the gold or rather promises for it at a low rate to Bellaria. Later, after his announcement, he loaned to others. He said he would not do this again; he said the same to Bellaria: "You need bigger reserves and a government that is willing to rescue you. This is bad, very bad." He had not expected such a bad bubble and its following recession. "Too many people invested too much in land and houses on the premise that their prices would always rise. There are a vast number of greedy rich people, even if their portion of the total world population is small. You can expect down turns; they will happen for several more lifetimes. However, recessions should not be as bad as this one, except perhaps once every lifetime or so." He laughed since he could not grin. "You are in the middle of what is likely to be the worst recession in your lifetime. It is the first since we started industrializing. Fortunately, the recession has almost nothing to do with agriculture,

which is not yet modern. Unfortunately, our enemies will say a great deal about this.

"Eventually the price of land and houses will stop falling, investors will gather money, especially from agriculture, and new businesses will begin again. Agriculture will be useful in two ways: it will provide money to investors, and it will provide food and an occupation to people put out of work by the crash." Djak would have frowned in thought had he been able. Bellaria was visiting him in the courtyard. He was the 'large, flying creature;' he did not have a face as such; he was thinking, not upset. He spoke to her specifically. "Some new businesses won't have to begin again. They will just grow faster. Examples are all the companies associated with electricity. The advantages are great. I bet" — he was speaking to and thinking of Bellaria — "most of your sales are to companies associated with electricity.

"Meanwhile, I am going to have to be the lender of last resort! Build up inventories of tools; that will keep people working. Buy more warehouses to store them. That will provide money to the builders. Your experts like working. Not everybody does; keep yours. Besides, it will be a good use of my loans.

"You will notice I am not giving you the money. That would work just as well in the short run. In the long run, it would increase jealousy because the question would be, 'why are some businesses getting free money.' I will loan to others, too; that is what I mean by 'lender of last resort.' I will introduce enough to influence the interest rate. That means anyone can borrow. The interest rate has gone down anyhow because no one can afford to borrow. However, our goal is to increase the velocity of money as well as its supply. This may cause a little inflation — that was what the price rise in land and houses was. Then it fell. The price of land and houses deflated, and now everything is deflating. Of course, when the velocity of money rises to normal with money supply going up because of me, we will either have inflation or more production. I hope by that time we will have the capability for more production. A little inflation is not bad but more than a little is horrific. At least, that is human history; I suspect it will be the same here.

"In the meantime, you and Glatist and everyone else need to figure out how to provide productive work to experts who otherwise could do nothing except live off their savings or else starve. I'll explain to all who take loans from me what and why I am doing as I am; some will pay attention; many will not.

"Everyone needs productive work, especially those unproductive people who work in more backward industries. The word, 'everyone,' does not only apply to the managers of new businesses; it applies to everyone who works, including those in old businesses. My advice is that it is important to get ideas from every hexapede. My advice comes from the history of humans and may not apply to hexapedes. To survive, we,

meaning 'you and other hexapedes,' can have no one claiming an idea is 'not invented here.' This is one time when it is fortunate that 'not invented here' is not part of your culture. As a group, you pay attention to other hexapedes. You pay attention to me! That compensates for the bad results of hierarchy, which, as a practical matter, tries to be a form of organization that is stable and soothing. Of course, 'outer direction,' as we call it, conflicts with my endeavor to create more scientists. To discover reality, scientists must pay attention to their experiments rather than to others' dreams. They need to ask difficult questions and be independent; they upset others because they are seekers as well as provers. They must be inner directed."

Bellaria moved up and down, the same as nodding for humans in the right culture. Producing inventory was a good idea, as was buying warehouses to store it in. In effect, the business was enjoying a very low mortgage rate. Then Djak said, "You should borrow money for warehouses from a bank." Seeing her expression, he said, "Don't worry; the bank won't charge much. There was a period on Earth when big banks were an oligopoly and small banks depended on the big, so they all charged a huge amount; but here we have competition, though there aren't many banks. When they borrow from me to loan to you, they will only charge extra to keep themselves employed. That will be good. I'll have to make my loans be for items that last less than a dozen years; mortgages can be for much longer. Initially, you'll pay the interest and capital on mortgages with a loan from me. Even the combination of the two interest rates will be less than you will pay after business gets back."

Bellaria nodded again, which is to say, she moved up and down. 'If business picks up,' she thought, 'we can pay the loans and the extra inventory will be useful; if not, most of the loans, directly or indirectly, are to Djak. He won't be hurt. And when you think in monetary terms, most of our equity, the various parts of our business, is in small pieces spread among a great number of people, so disaster won't matter much, either. I suppose if all the new businesses collapse many people will be hurt, but I don't think Djak is going to permit that. It seems to me that he really does want us to advance and become as good as humans.

'The world is finite; it is a ball. Djak is already talking about avoiding the worst of the mistakes of the humans; he is talking about sustaining production forever without much pollution.

'Meanwhile,' Bellaria continued to think, 'if it were not for this down turn, we would be growing. So would every other new business. Djak said it was the result of a bubble in land and house prices; I like the metaphor of 'bubble.' Now the 'bubble has popped' even if this 'bubble' lasted a long time. The consequences last a long time, too.' She did not think at that time to question how the bubble came to be.

"Economic growth will continue for several lifetimes; then the economy will become stable. However, technical changes will continue," said

Djak. “There may be fewer changes, but the frequency of those that do occur will still likely be high. We can expect that changes will happen more often than generations. That is not stability. First of all, it means scientists. So we must have changes in our education and the children of the poor must go to school.”

‘That means agriculture must change,’ thought Bellaria. ‘We will see what Djak does; he hasn’t changed plants or anything, just compost.’ Bellaria did not think of steam engines as having anything to do with agriculture, although they did. She did not even think of the use of steam-powered boats, which would reduce the cost of hexapede transport of food. However, she was correct in thinking that ‘There will be no more children as scarecrows.’

Chapter 28

At first, Djak hated being the 'lender of last resort.' Then he realized that he could influence new businesses; then he realized he could not. He was introducing so much gold that he was influencing the interest rate. Anyone could borrow.

He and Djil were the most powerful entities in the system. Djil was hidden. From his point of view, she was mainly useful to talk with.

Djak explained his conundrum to her and she responded in a way that surprised him: she quoted him. She discussed the structures of social life and his statement of them as preferences; and then she went on.

She said, "You are more a director than a reporter; that is an old computer science and popular psychology distinction. For computer scientists the word for 'director' was 'actor' and applied to computer programs as well as to people. For popular psychologists, the word for 'director' was 'director'. Directors direct; reporters report. Being a director is why you want to influence new businesses. However, influencing the interest rate as you have done is more important in the long run. There is going to be technological advance no matter what. We are just speeding it up and preventing the worst disasters."

"How does influencing the interest rate prevent disasters?" asked Djak.

"It doesn't as such, not directly. You need to introduce the right laws, too," said Djil. "Otherwise, the biggest thugs will borrow the money and spend it wrongly, however attractive they are. Thugs are always in governments; after all, governments are thugs. The question is how good the governments will be. Rulers can escape local pollution by moving into upwind suburbs. That will solve their personal problems for the next few lifetimes. They may not want to hurt themselves with bad global impacts.

"To prevent eventual problems, you must introduce the right laws now into the Glemrian legislature and the legislators must pass them. You will also need to persuade the emperors and their supporters in foreign countries. You will have to avoid competing with them; you can do that. They are thugs who won't want competition in their business, which is ruling. If you provide such competition, they will oppose you.

"I suppose some laws can be exported from Glemria, such as those which have to do with imports. Others cannot be. Paid security, what you call income transfers, will enable adults to think about everything in the long term; they will favor education, too. Those laws cannot be international. Local Glemrian laws don't help in foreign lands. In addition, income transfer laws will hurt many local and even national powers, especially before tax receipts increase."

"The nearby empires have aborigines living in their bad lands; they have been pushed away from their good lands," said Djak.

"Yes, and we have them in Glemria, too. Consequently, the initial social security laws will have to apply only to cities. That will make cities more attractive. We can ask the hexapedes for help with details, like how big a city, how far from the city should we pay, and do we calculate distances from the city center or from walls for those cities that have them? Attractive cities should help keep down wages, too. That will ensure the happiness of the greedy powerful.

"Are you going to implement and suggest agricultural improvements, such as better plants?" Djil continued to ask, "You are going to do more than give examples of composting, are you not?" Then she said, "The hexapedes cannot continue to have more than two-thirds of their population growing food for the rest. You must cause people to move into cities. In them, you'll ensure that wages will stay down because of the movements of huge numbers of agricultural people.

"Let us hope that none of the rulers oppose these laws too much."

"Yes," said Djak. "I'll learn what the most common sources of food are and engineer plants to grow them, at least, that is what I will do with vegetable foods, the equivalent of wheat and rice among humans."

"Among humans," Djil said, "they are called cereals."

"I meant vegetable as opposed to animal," Djak said. "I'll discover what their biggest predators are — I suspect they are microbes — and engineer plants to resist them. At least, I won't make the same mistakes as humans, especially with plants' resistance. Humans have already made those mistakes. It is all in my library." He would have made a grimace had he been able. "My reason for helping them is that, unfortunately, the hexapedes are at a low technological level. Now and perhaps for a gross or two of years they won't be able to make any modifications except by breeding. Breeding is too slow; we need engineering. I'll make mistakes."

"This planet has different ecologies," said Djil. "Just as the different big and small ecologies on Earth led to different problems, we can expect the big and little ecologies here to lead to problems."

"I can figure out the big ecology on this planet and I think I can handle the engineering of the small ecologies. In any case, Djil, you are right: we need local hexapedes to grow enough for everybody; and they need seeds to satisfy farmers' needs. A couple years of growing should help."

"A couple of years . . . ?" Djil asked.

". . . or three years," said Djak. "Farmers will grow many seeds themselves. We won't prevent that. We won't be like some of the powerful organizations on Earth, who only sold sterile seeds. It started benignly, but became evil. I suppose some organizations here will try to do the same; or at least, they will after everyone understands the technology. After all, if farmers have to come back every year, such companies will have assured incomes. We can prevent that and force them to compete."

Chapter 29

In the main room, Glatist flowed over a chair, pulled his feet into the legholes, and sat in front of the dinner table. Bellaria had not cooked the meal – that was done by the cook. It was laid out and getting cold; the cook was not. Unlike those who had become accustomed to cooks and were much richer, neither Bellaria nor Glatist had thought to insist she be there. It meant she only cooked one meal a day, the dinner, not breakfast or lunch. Bellaria and Glatist did not have a big house, either. Glatist fed the fire in the bedroom when he woke and put a kettle on it. Bellaria made a hot beverage after the water came to a boil, but for both of them, breakfast was at their business, as was lunch. Bellaria sat at the dinner table, too. She spent the day being an accountant and setting prices with her father.

Glatist said to Bellaria, "Today, I was asked to loan money to support the development of a strange machine. It stuck out weights on one side so gravity could pull it down; it went around. The man who wanted me to loan him the money said that the planet is so big, its loss of energy to the machine would be minuscule. He did not quite smell right so after he left I spoke to one of Djak's sensor/speaker combinations and asked him. He was in his courtyard. After telling me he was there, he did not say anything for a long time — now I suspect he was laughing, although I am not sure." (Djak had already heard and seen the man come in, but did not tell Glatist that. He was laughing at himself.) "Then Djak said, 'You have been offered a perpetual motion machine. The direct and indirect energy for pushing out and pulling in the offset weights, plus friction, more than compensates for their falling. You have a machine that comes to a halt. I did not expect this here; it is like humans on Earth in the Victorian Age. That was during the first industrial revolution. Your confidence man's patter was good: if you had heard something about planets transferring energy to smaller bodies, but did not know anything, his lies might influence you. You have run into a trickster.'

"I said that I'd been asked to loan money, not buy a machine, and that I hadn't done either. Djak said, 'Good, I am glad you asked me. If the fellow comes back, arrest him! He is trying to commit a fraud on you and probably on others. If you had not told me otherwise, I might have thought he believed in his perpetual motion machine, He knows too much. He is trying to be convincing.' "

"I told Djak that the fellow had not smelled right, literally. He said, 'Then it is most likely the man knew he was lying and did not like doing that. You will run into frauds who do smell right; at least among humans we do. They don't care about you at all. What those humans are doing is seen by them not as a lie but as a ritual that sometimes brings them money.' Djak paused for a moment; I think he was thinking more and not telling me. Then he said, 'Frauds don't think of their patter as a ritual, but as a gambit.'

"I said that the fellow probably was a fraud who did not like what he was doing. Djak agreed, and then said, 'We could pity him, but many others do not try to extract resources from you. In addition, the man who does not care about you at all should be pitied more since the affliction is often inborn, at least among humans. Of course, you could be wrong about his smell.'"

Glatist continued, "Djak also said to me, 'A man without a bad smell might be a member of an organization that is trying to transfer resources from the rich to the poor. He would believe. You are richer than most. However, you should be supported because you and Bellaria are organizing the production of good tools. In current and I think in all situations that means you will have more income than your employees. The amount more is dependent on culture. It may be twice as much; it may be six times as much. It cannot be extreme because then your employees stop being yours. You lose legitimacy and depend on fear and stupidity. In addition, you will have the problem — by 'you' I mean certain hexapedes — that while many don't care for more than a minimal amount of money, those hexapedes are more likely to ask questions. In addition, there will be people who organize against you.

"'Many rulers on Earth don't like anyone who can organize. That person is a potential rival. By those who 'don't like,' I mean certain private or public rulers, private company managers or public government politicians.' Djak was saying this to me. 'They won't like questions, either. Questions show mistakes or their followers' mistakes. Such rulers want to copy the engineering that is useful to them and avoid difficulties. They create stupidity. So a man who tries to rook you and does not smell bad either belongs to a stupid organization or does not care about you. It is unlikely you have stupid organizations yet, so a man who does not smell bad probably does not care about you personally. A man who smells bad and tries to rook you sees all as zero-sum. You were wise not to give him any money.'"

"I think we are seeing an increased number of frauds," said Bellaria. "Perhaps the portion of such people in the population has not grown; unfortunately, opportunities have. We are in the middle of a change that many, probably most, do not understand. It is like a drought in the old days, except we are causing the change. In the past, djinns or devils created bad weather and mountebanks attempted to take advantage of that. Now we are causing disaster for some and the need for cheap energy for others — that is what a perpetual motion machine is, cheap energy — and fraudsters try."

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The man tried his scam on another possible investor. Geldrit saw through the man and arrested him. Geldrit was smart and courageous enough to hold and charge the man with fraud. Djak suddenly realized

that none of the hexapedes had a police force. The cities felt to those living in them as villages in which everyone knew everyone else, although cities were too big to know everyone.

The same happened with fire, with burning houses. People brought out their buckets and formed a line from the nearest source of water, which in a small village was a river, stream, or pond. Cities might be located on a large river, but most areas in the city were not as close as areas in a village to a sizable amount of surface water, not that chains of buckets helped much anyhow. Cities needed a publicly-paid fire department with good technology; and house holders needed insurance. So did villages, but not as strongly.

Djak had presumed the hexapedes had police. Among humans, the later Romans had police and they had a lower level of technology than the more advanced hexapede countries. The Romans suffered an agricultural technology although their conquests enabled them to have a few large cities. The Middle Ages on Earth were different. It turned out that the hexapedes in Glemria had a few civilian police but mostly they depended on their army. Usually, it did nothing useful except transfer income from the government to the soldiers.

Geldrit took the man he accused to a judge. The Glemrian government said that although citizens could seize another for breaking a law, only a governmental agency could hold an accused man for more than a day, with several days being permitted where there weren't any close government agencies. The judge represented the judiciary. He could restrict the movements or imprison an accused man. If convicted of a crime, only a judge could imprison a man longer or punish him in another way. To prevent corruption, no judge could give out rewards which leading hexapedes figured would be more effective in causing change, whether it be of police or crooks. They thought well of rewards because in their minds they scaled up smaller experiences in changing people's behavior. The hexapedes did not permit any large scale rewarding because they considered the transfer of monies from the government to individuals as temptations or 'moral hazards,' as Djak called them. They did not think of their army and navy as temptations, not even for the senior officers or contractors. The hexapedes in Glemria knew that corruption could break out again when corrupt people were given sufficient motivation. Corruption could break out even with restrictions.

Djak was not sure what to do. In Glemria, he figured that his social security plan was going to have trouble. As for the army and navy, no one thought of either as receiving income transfers. Only when they were defeated would people think of them as recipents. Also, Djak knew that individual thugs would gain enough power to beat an army or navy only after several lifetimes of technological development had passed. With the current technology, you needed an army to beat an army. The introduction of peacetime pay and extensive training meant that

the main challenges in the current army would be to prevent excessive stupidity and to adapt new technologies within a generation.

Chapter 30

Djak thought more about the neighboring empires: both were run by smart rulers. Both were traditional; that is to say, their countries fought although their leaders were safe. They weren't as traditional as their predecessors of a long time ago when governmental leaders were also military leaders and at the head of their troops. Glemria was too weak to fight. War was a waste anyhow.

'More importantly,' Djak thought, 'beliefs have to change everywhere — the beliefs of most people. The Empire of Fortenst will oppose the Empire of Ildong as it always has, even though fighting will be a waste. Fortunately, they probably will not fight.' Still, he knew that beliefs in Fortenst had to change as well as those in Ildong. The Empress of Fortenst was as competent as the Prime Minister of Ildong but neither had any mechanism for dealing with technological advances.

Djak decided that his best action was to let the two empires collapse. They would eventually. All the dictatorships would. It would take several generations. Either a new generation of hereditary rulers would prove incompetent or the countries would not adapt quickly enough. He expected that during the time waiting for collapse, no irreversible changes would occur besides the death of hexapedes. Technology was insufficiently advanced. 'People will die before their time and advances will be slower,' thought Djak to himself; 'at least, I'll prevent wars. I should focus on Glemria.'

Meanwhile, Djak decided to scare the Prime Minister of Ildong. He had simply forgot to do it earlier. The man was dangerous. The Prime Minister, Kelding, had heard that his Emperor as well as his enemy, the Empress of Fortenst, had been visited in their gardens by Djak's talkative 'birds.' As a consequence, he was always undercover. He never left a building although he personally had not seen the bird that came to the Emperor's garden.

Djak's new 'bird' carried a small quantity of nano-disassemblers that would only reproduce a certain number of times. They would not destroy everything, only make a hole in a wall big enough for the bird to go through. Because the bird had many ways to prevent a nano-disassembler from reproducing, it was very unlikely that a mutation could enable any to have many descendants.

Through his window, the Prime Minister saw a strange bird which he thought had to be Djak's. The bird looked like the hexapedes' equivalent of a crow, although there were none in the capital city. The bird also looked at him. While Kelding was still looking through the window, and not seeing any bird, a hole appeared in the wall. It was in an outside wall. A little of what appeared to him as smoke but was a very fine dust came out of it and then the same bird as he had seen before walked to its exit and flew around the room. The hole appeared in the thicker stone of the wall, not the glass of the window. Although the

Prime Minister's window had thick glass that could not be broken by a big bird, his stone wall could not be destroyed by anything less than a cannon ball.

"We have advanced technology," said the bird, still flying. "I could have killed you. Be a responsible and peaceful dictator; then you will be all right. Don't imprison or kill those who ask questions or innovate. We don't care about you as a person. However, you are better than the Emperor, so you can continue for a while. Push for competition and transparency; that will be difficult. There will be many other changes, too; you cannot avoid them." Then he vanished back into the hole. Through his window, the Prime Minister watched the bird fly away.

The bird's hole had a flat bottom, straight sides, and a curved top. It was big enough for the bird to walk comfortably. Kelding was not comfortable, and it was not simply the hole though stone, although the hole let in outside air; Kelding was scared. He had not understood how 'advanced' the advanced technology was and suddenly realized he could not conquer the world; indeed, he could not do many of the things he had planned. Fortunately for him, he was very fast at adjusting his life.

He called in his guards who were outside the room in the hall. He pointed silently at the hole and then spoke, "Fill it up. I had a visit from one of Djak's birds."

The Prime Minister carefully dropped charges — they were all false — against those who had asked too many questions or had tried to innovate in ways he or his supporters did not like. Those prisoners were released. 'They will cause me trouble,' Kelding thought. 'At least, I have not killed anyone. I guess I will never be able to kill my enemies.' His mouth pursed. Then he remembered that the bird had told him to push for competition and transparency, too. 'No monopolies . . . that means I'll have to go against my supporters; what will I do?' He thought for a moment and then determined to repel them one at a time: 'Divide and conquer; they will gang up against a loser; they don't think ahead or learn.'

Kelding decided to meet Jankun, the most powerful of his former prisoners. "Since you don't trust me, I'll meet you outside in a field where I can have visible guards and you can have hidden guards. You can choose the field. Pick disciplined men, since they will be armed and we don't want trouble. My men will not shoot unless fired upon." He thought he had understood the significance of the bird's hole: for him, no place was safe; he did not realize that Djak could not see under covers and could only hear in rooms his sensors were in. He could have built several offices without windows and chosen them randomly. So long as the new offices did not have what to Kelding were invisible sensors, he could speak as he always did. But Kelding did not know about sensors or other of Djak's limitations and went outside. His former prisoner understood that Kelding had changed. Jankun did not know why — his attempts at bribing his way into Kelding's innermost circles had

failed — still, the man had clearly changed. Jankun wondered what Kelding was up to.

The field was in a large park overseen by buildings. They were where Jankun had hid his guards. Kelding's surrounded him closer in. He offered Jankun a new post, that of 'change coordinator' with income and a position in the cabinet. Kelding also said he would permit some legal opposition. Rather to his surprise, Jankun declined the position. "I like to be at the top; we would always fight each other. I am better as the head of an opposition party — or a ruling party." He grinned. "However, a young person would do you good. He, actually I am thinking of a 'she,' would know more of the future, be a good substitute for me, and be competent; I am thinking of Djella." Jankun knew himself and his followers well. He knew he was aggressive. Moreover, his followers would not accept an alliance. Djella was different. She was young — less than four dozen years old; no one would think of her as having the power to make an alliance — and would like the post. She would be good at it. Besides, she would learn about Kelding's official workings and report them.

Kelding remembered Djella; he had imprisoned her. He was not going to change her beliefs but he had to admit, she had been good at administering illegal organizations before she was imprisoned and would probably be good in the cabinet and administering a legal organization. 'She'll be a spy, of course.' Nevertheless, he was not going to persuade Jankun to change his desires.

So, after a moment in which he paused and thought, he said, "OK, we'll ask Djella. How are you going to get into the legislature?"

"You will have to call new elections, honest elections," said Jankun. "Neither me nor my followers should have any trouble. You can make sure we don't dominate the elections, as we would regardless of the good things you have done" — he grinned ferociously — "by counting our numbers. We'll do that, too, and make sure we run a number equal to a third or so of the legislature's total size. Your party members can avoid being overwhelmed by votes for us by not standing in any one of our constituencies to oppose us. Your people can run for office in constituencies where we aren't."

After a moment, Kelding moved up and down; he said one word, "Yes." He knew he and his supporters were not as popular as he wished. Nonetheless, Jankun did not have support from the police and the army. That is why Jankun was not Prime Minister.

Chapter 31

The local powers resisted an industrial revolution because they saw it as reducing the subservience of others and losing them money. They saw the situation as zero-sum, as in agricultural times, rather than positive-sum. A few understood that eventually it would not cost them any money but others would be less likely to cringe. Ordinary people would become more independent.

Djak decided to delay his land reform in Glemria by a generation, even though he figured that land reform would increase agriculture's efficiency. Although the delay would prevent reducing of the size of large plots to smaller ones (by exchanging bonds provided by the government for tenant's land and making them be independent farmers), the delay would also prevent the tenants from wanting to farm since they would feel forced rather than be owners. The feeling was not rational; either way they would starve if they did not cultivate. On the other side, a generation would enable new local leaders to gain power; perhaps they would not want as much subservience as currently, although they would have grown and been educated before Djak and Djil came. Djak hoped that eventually most local leaders would prefer greed to pride. In addition to the general improvements due to technological advance, the new leaders could gain more money to spend by investing in a wide variety of new businesses.

Djak was stymied by cringing. He could solve the monetary issue, for example, with land reform. He could not solve the subservience issue. Meanwhile, the local powers in Glemria persuaded or fooled enough people to make up a large group of followers. However, it was part of the army in the neighboring land, a colony of Ildong, who had separated from the others in the colony and planned to attack. The attackers were persuaded by local powers. They thought that their attack would stop technological change, especially that from the neighboring country of Glemria. They were wrong. The hexapedes were going to change regardless of the efforts of the interstellar travelers. War would push change expensively.

Nonetheless, Djak still continued to ask himself, 'Should I push for the legislature to put into the eventual law clauses to prevent anyone from selling bonds immediately? Or can I count on enough local powers delaying so I do not have to have the legislature force them? Indeed,' he wondered, 'can I persuade the legislature of anything at all?'

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Three assassins came upon Glatist as he was walking home through a small wood. The assassins were riding. They had not expected to see him there and had not prepared an ambush as they planned. Nonetheless, seeing he was alone and apparently carrying nothing that could be

used as a weapon, the three pulled their swords from their saddlebags to where they were readily visible.

Glatist saw the swords. From them and from the assassins movements, he decided the three men were going to try to kill him. He was dressed as a civilian and carried only his two pocket knives. The assassins rode and put their swords in each of their two foremost hands. However, Glatist was so angry that he tore a small tree from the ground, pulling up its roots. He poked the top of it at the first assassin who was riding towards him with both his swords out. The rider got branches in his eyes and missed Glatist. The second assassin, seeing the harm to the first, slithered to the other side of his beast; but then he could not stretch his swords far enough to hit Glatist, although they came close. The beast was not fully armored since that would have been visible, so Glatist was able to stab it with a pocket knife. That caused the beast to buck and throw off its rider. The third man had stayed back and saw what Glatist was doing. He climbed off his beast so Glatist could not blind it. He planned to cut Glatist's tree with his sword and then kill Glatist.

The third assassin did not expect Glatist to throw his tree. It effectively disarmed Glatist but he did not see an alternative. The top of the tree blinded the third assassin as it did the first.

Then Glatist ran home, which was close. When he got there — it was dinner time — he told Bellaria at the same time he grabbed two double barreled pistols. They were already loaded, since that action took quite a time. He did not have armor or swords but the pistols had four shots and there were only three assailants. He could miss one shot or a pistol could misfire. Bellaria armed herself with six kitchen knives, although they would not have done much good if Glatist had been killed since the swords had a longer reach.

Suddenly Djak spoke. Neither Glatist nor Bellaria expected to hear him; they had not known about Djak's 'bugs' or his ability to speak through them. "I'll take care of the three assassins," he said. "I've not been paying much attention to you. You deserve protection."

Later Djak described his 'bugs.' "I first put them in the embassies of Ildong and Fortenst; I did not speak through them, so they were not discovered. Then I expanded. You are two people I try to protect. I have not attached anything to your clothes although I could and now I should. I monitor though a 'bug' and a non-sapient robot that can figure out everything that is said and decide whether to inform me or not. I can produce enormous numbers of 'bugs' and non-sapient robots although I haven't since I am trying to persuade. You are the first to learn that I spy in Glemria although I believe that Djinbit suspects. Please don't tell anyone. I have not told your government. Since the technology is so advanced, it will be lifetimes before you can duplicate the 'bugs.'

"Hmm," Djak said after not saying anything for a period, "people in your neighbor, the colony of Ildong, are behaving differently from usual but the change has not crossed the threshold for the robot to inform me; I am investigating its logs. I am looking at visual changes, not auditory. I should dispatch some 'bugs' so I can hear. That is the trouble with the satellite imagery that is all I have for most of the world; you can't hear anything. You cannot see underground or inside a building, either, but that is less important. All we would see are meetings. It is what they *intend* that is important and we can't read a mind; we can only hear them speak. I'll send a 'bird.' It can carry a bunch of 'bugs' more quickly than they can fly. I guess I should do the same with your northern neighbor as well, although the people there have done nothing suspicious that we can see. Setting up will take a little longer since your northern border is farther way."

A few days later, Djak spoke again, this time at the business. He was even quieter than before although that was not necessary; the business workers had left. He spoke through a sensor/speaker combination. Both Glatist and Bellaria were working late. No one besides Glatist and Bellaria could hear or learn of his existence any more than they could the first time. Djak spoke: "The enemy's plan is to fight a civil war in your southerly neighbor; they expect to have the major and perhaps the only battle there. Then, they will invade you. Evidently, some soldiers changed sides and what I thought were people practicing for village defense were non-soldiers learning to be soldiers. The soldiers kept their own weapons and stole more; they provided the extras to those villagers.

"News of the failure to assassinate you has not yet reached their leaders. In any case, they don't expect Glemria to invade after your government learns of your supposed death, even if a civil war is going on. They only plan to control land on this side of the ocean. I will have to fly there to make robots to go between the two armies. I should have listened earlier; then I could have frightened their leaders, the way I did with the leaders of the two empires."

Glatist and Bellaria had heard accounts of the birds; the actions were attributed to Djak. However, they had never heard him say that.

Chapter 32

Djak told the guards in his court yard that he had suddenly to prevent a civil war in the colony to their south, and rather to their surprise, took off vertically, stuck out wings, and disappeared quickly. They had not expected the wind they felt when he left, either. "The wind has gone away," they said to each other. They wondered whether it was a side effect of the 'flying creature' taking off vertically. They woke their boss, who had gone to bed early, and told him the creature had left. He, in turn, woke and told Nerrig.

Nerrig woke, came out, and saw that Djak had indeed left. All that remained was the extrusion 'for gathering energy from the sun' and connected to it, a box of some sort. Although the commander did not know it, the box contained a battery, a smart although non-sapient computer, a radio transceiver, protection, and a few other items. Looking at the extrusion and the box, Nerrig said, "It appears as if the flying creature is planning to come back. Perhaps he really is going to prevent a civil war." He went back inside and prepared to go to sleep. He was smart enough to realize he could not influence Djak.

Djak landed well before dawn in the field that was the most likely place for a potential battle. The two armies were camped at the opposite ends of it. Djak stopped on one edge of the center and walked across it producing robots from dirt. He constructed two ditches, on either side of himself. The ditches accepted extra dirt from which certain elements had been removed. The elements had gone into the robots. The remaining soil from the ditches was spread over the surface of the field and not visible. The ditches went from edge to edge of the field and were longer than the opposing armies.

During the night, those sentries who had been awake and closer than the rest had not seen anything since the center of the field was a little lower than the ends; as a result, neither of the opposing armies could see the ditches or the robots. Before dawn, every robot had descended into a ditch, on one side or the other. They lay on their backs and held a segment with grass on top so it appeared that only Djak was between the two armies. The grass, a kind of lichen with deep roots, had not had time to die.

At dawn, most of the soldiers woke and saw Djak. He was rearing up. After members of the two armies stopped being amazed, Djak spoke. "You are not going to fight each other," he said in the two languages of Ildong and Glemria and with such loudness that his message was heard by both sides. "You are not going to kill anyone." At that point, Djak had his robots push their segments up and step behind them. The segments were quite shallow and had fused dirt on the bottom side. After the segments made walls, the fused dirt was on the side that faced each army. Djak figured the walls would make a good show; they could stop a single soldier but not a battering ram. The ditches were another matter. Front soldiers saw a ditch, a wall, and a line of robots

standing on their back legs and vertical rather than horizontal. The position was unusual and scary. Half the robots faced one army and half faced the other. Taller hexapedes could see the top of a farther wall; they could not see the other ditch.

Djak said, "Your leaders will negotiate. I expect most of you 'rebels' will rejoin or join the regular army. I expect a total amnesty. I know that one of your leaders is not supposed to do anything besides put down this rebellion but that is irrelevant now. I grant him the authority to negotiate." Somewhat later, he returned to the courtyard.

Chapter 33

Grindel saw that Mankof failed to kill Djak and decided to capture or embarrass him with a lure. Among humans the method was old and known as a 'honeypot.' Grindel could not use sex, a normal technique, since Djak was a different species; he was not even a biological human! Grindel understood that. Grindel figured that his only choice was to use knowledge. Most knowledge would not work, since the humans were so much more advanced than the hexapedes. But the knowledge of who was behind the attempted murder . . . that would attract Djak.

Grindel did not want to implicate himself, so he hired another man who in turn hired a "lowlife". Grindel gave the first man false information to pass on; not entirely false: he correctly described the man who hired the attempted murder as a local power but did not describe himself. The "lowlife" was supposed to be the go-between.

Djak foresaw that he might be lured by a honeypot and hired another hexapede to serve as his contact if someone tried to come close. Besides paying him Djak said to his contact that he, Djak, would pay the other for the information once he described his principal enough for Djak to identify him. Djak said, "You know that I will keep my promise to pay even if he is not very trustworthy."

Contact was duly made. However, Grindel's go-between could not identify 'his principal' sufficiently and Djak refused to do anything. Since the contact was between hexapedes on each side, the go-between in Grindel's side and Djak's man on his side, Grindel himself had nothing on Djak. The go-between asked his boss what to do. The man asked Grindel, who told him to forget it. Grindel was irritated. "That didn't work. I'll pay you the amount we agreed; then we'll separate. I can't think of anything more."

Chapter 34

Because of the rebellion in Ildong's colony, uncertainty among Glemrian investors had increased; then when it ended, uncertainty decreased but not all the way to where it had been before the rebellion. More uncertainty required more overt returns, that is, returns that handled a world that included uncertainty.

The rate of return depended, in part, on uncertainty; less uncertainty implied a lower and more uncertainty implied a higher desired rate of return. That is why land was such a good investment and returned so little: investors did not expect farming to produce less or rents to go down. Djak produced fewer gold-backed promises as he did not expect either his actions or the increase in uncertainty from before the rebellion to create a recession. Also, after the end of the nearby rebellion, the velocity of money and its substitutes would increase. That could cause an inflation and, perhaps, an increase in industrial production. The changes in velocity were not due to Bellaria and the people with whom she talked. They were due to other, more optimistic people. In practice, since it was still a mostly agricultural society, such an increase would have led to an inflation except that Djak reduced the numbers of even more of his promises. He kept the price level the same and the interest rate low but not too low.

Bellaria did not have much personal money but she had some. As far as she could figure, her best action was to do nothing with it, not to sell or buy any stocks or bonds at all.

Equities rose in value but not their true returns. The changes required an investor to leave aside the monetary effect. The change in the price of equities was mostly imaginary. Taking into account risk and the natural desire of companies not to pay anything at that time, returns were very close to interest rates. The change in price was rational. Most investors saw that the price of equities had gone up with the decrease in uncertainty. Nonetheless, they did not appreciate the uncertainty and risk that each equity still had. Many liked the increase as they could sell what they had. Others did not like it since they depended on returns for their income. True returns had not risen.

The lack of information made it all harder. Moreover, without mechanical computers, the hexapedes had to depend on themselves. They were slow. Only Djak had mechanical computers, that is to say, electronic computers. He lacked information. Just about all he could find out were current prices as well as current interest rates, which were prices of a kind. At least, he knew a considerable amount of theory. One of his theories was that new businesses organized with new technology would produce more goods. Provided with money and with increases in production and competition, prices would drop unless the velocity of money went up or he increased the money supply, which he could do by extending more promises. Djak knew that prices could

drop, which would benefit creditors more than debtors since creditors could buy more when they were paid back.

Djak's main problem was a lack of information. No one he knew had collected prices over time. He suspected that no one had. He could produce robots that looked like insects. Groups of them could pull out old business records that mentioned prices and investigate them at night. He would make sure that no one would see vast numbers of insects. Yet why search? It would be a good job for hexapede historians. Djak finally realized that all he needed were the current indicators.

Djak preferred neither deflation nor inflation but stable prices, not counting those prices which had to do with good and bad weather. They influenced agriculture and the price of food. People, especially poor people, had to eat less as prices rose when there was less food. He calculated several consumer price indicators. Then he realized that as competition increased, the prices associated with businesses in more advanced technologies would drop over time from being just under the prices of handmade goods. So he did favor a little deflation, a small and continuous drop in prices. That was for businesses in industrial technologies. For him, it was trivial to separate agricultural prices from prices in industrial businesses.

Glatist told everyone that he had been attacked and what he did. Djak did not have to do anything. It was no surprise when the army found two blinded men wandering among the trees and one dead beast, which Glatist had stabbed. By it, two pairs of swords were found where they had been dropped. The army report hypothesized that the second man had been thrown from his beast before it died, stole the third man's beast, and rode away. The other living beast was never found, although it had a saddle and bridle on it. Presumably, it followed the third beast. The army stopped looking for the second man; they assumed he had gone back across the border where he would be surprised by Djak's peacemaking and amnesty.

Bellaria heard of the ending of the rebellion and decided that the danger to her was less. Finally, she decided to invest.

At the same time, she relaxed. Instead of unconsciously holding her hands out, she bent them at the elbows of her internal skeleton and let her upper arms fall vertically; none of her hands touched the ground. Although her skin was tougher than humans', it was not tough enough to drag — or slippery enough. Skin could not be dragged while a proto-hexapede was starving. Dragging or holding hands out did not mimimize food use and such proto-hexapedes failed to pass on their genes to successors. Bellaria was one whose ancestors had survived; everthing living was; that was evolution. Her ancestors did not drag their hands or hold them out unnecessarily; consequently, she could do both: bend her arms to avoid dragging as well as hold her hands in front of her face.

Chapter 35

Djak found it hard to engineer plants. He needed information from hexapedes. That information did not yet exist since there were no hexapedes with the requisite information. He talked to Djil. She said, "Plant several rows from each species. Only five or six are important for food, directly or indirectly. Your discoveries will take a little longer. At least, you will be able to discover what limits the plants. Besides spacing seeds and all that, you might supply each of the types with various combinations of nitrogen, carbon, potassium, calcium, magnesium, and phosphorus just in case they are like Earthly plants. We don't know what limits them here. If they are symbiotic with microbes, that is all to the good. Or it may be something like selenium, which limits plant growth in certain places on Earth. You should also analyze the burnt ashes that Bellaria sells to Gildar. You can find what's in them. They restore vitality."

"I want to do more than restore, I want to increase plant production," grumbled Djak.

"Yes," said Djil. "Nevertheless, an analysis of the ashes should give you a hint. At least, since ashes succeed in restoring a plant's vitality, we know that some of the limiting factors are not grown. I don't know about microbes."

"I am glad you said 'for restoration.'"

"Yes," said Djil. "We really don't know what limits increased production, only how to restore it to its current level. The limit is not water since plants close to rivers don't grow any better than those far away. Drier regions won't be so lucky as to have water, even if they do have sunlight.

"In any case, whether or not in areas with low rainfall — they could be anywhere although most likely they'll be at certain latitudes — we don't want hexapedes to drain water from aquifers quicker than they recharge and not from fossil aquifers ever. Humans did that and eventually lost. It is not sustainable. Only a few generations did well."

"We don't have to worry about that. Hexapedes do not have the technology for cheap and really decent pumps yet," said Djak.

"They will within a short time, a few centuries at most. (To be like hexapedes, I should say 'within a few gross of years.') The time may be less. After all, electricity should be common in a generation or less and pumps are clearly useful. The price of steel for building pumps has to come down as well as the current price of energy. Good pumps already exist and their price is moderate: too much for agriculture but suitable for family houses. You are going to reduce prices, right? Pumps can empty aquifers. I think you should pass a law against excessive exploitation of aquifers and against draining fossil water. You should do that now before any one becomes dependent on excessive exploitation."

"How should a law define 'excessive exploitation?'" asked Djak.

"I am not sure. Let me think." She paused. "At first, before wider information is available, simply say that no farmer can feed his plants from an aquifer with more water than falls from the sky on his acreage in an average year. That will effectively ban fossil water withdrawals. The amount falling determines the types of plant. As for aquifers that are full of fossil water, we can monitor them over time. Most cover several farms so we won't have to drill too many holes or depend on dishonest farmers records. Most farmers are honest; we should be able to find the miscreants.

"We will have to deal with the minority who already irrigate their plants," said Djak; "mostly, they depend on rivers and the like passing water into ditches."

"Yes, we will," said Djil. "We will have to be a bit more specific. Perhaps we will have to list types."

"By the time the price of steel comes down," said Djil, "it may not be necessary to talk about rainfall on a farmer's land. Everything will be irrigated; no; we will still have to talk about rainfall for those who depend on it. Also, in case the farms are big or for some other reason, we should keep the 'single farm rainfall' in the law. The total water falling must include rain that falls on the plants themselves. By the type of seeds the farmer plants, we can determine roughly the amount of rain that falls in an average year; after records have built up, we can take the average of the last twelve years. Eventually, we can set it up so an aquifer compensates for a year or two of drought. In a sense, the aquifer will be a big cistern."

Chapter 36

Djak thought about what he was doing. Steel, textiles, fertilizer, steam engines: to produce them required a great deal of financial capital. He could, of course, make them but he wanted the hexapedes to learn. The only way he could conceive was through manufacture. Only then could he be sure of everyone, of all the producers besides copiers or inventors: teams of those who recognized a good idea, pushed the product, improved it, made sure the notion was complete, acquired resources, and kept morale high.

Djak figured that before he and Djil came, a majority of hexapedes in Glemria had preferred to synchronize living organisms rather than speed up simple machines. They figured that understanding people in their group was better than any not-invented-here belief. Moreover, their total numbers were limited. Indeed, the population of every country was low and the majority in any location that claimed to be a country did not care to understand their aborigines.

As far as Djak could see only in war was there an advantage to making decisions quickly rather than persuade everyone through rhetoric. He was not even sure about that. After all, even in war one had to persuade people to fight; or rather, before war, one had to persuade people that a portion of them should die for their society, whether it be a world, a nation, or a tribe. Otherwise all would shrivel.

But war had been and was common. There was an advantage to hierarchy. Moreover, agricultural leaders, who controlled a slightly more advanced technology, tended to prevail over tribalists. Everyone wanted their children to have as good a life as they, even though children did not necessarily live up to their parents' hopes. In addition, besides having more material goods, the agriculturalists were more able to enforce an ascribed hierarchy of status than the tribalists. That meant that in normal circumstances the children of agricultural leaders would have a better life than agricultural followers or tribalists. The aboriginals were mostly tribalists.

Djak found useful for economic development only one social trait in his list of seven: that the hexapedes favored community over businesses that were just a portion of their overall community. Of course, the hexapedes had to have a big enough sense of community for such favoring to be a benefit. Otherwise, business people would not be able to sell enough to bring their incremental costs down.

The seven traits were not universal. They were not like the mathematical structures of social life that Alan Page Fiske had discovered: the equality, the lesser or greater than, the one operation, and the two operations. Djak had also decided that the structures of social life represented people's preferences. People preferred one but understood all of them.

People who preferred one and two operations also preferred abstractions; that did not mean they only talked of love and heaven which nobody could point to; they certainly could talk about something they could point at, such as displays of affection or a person eating well; it just meant they preferred abstractions. Those who preferred either equality or two operations preferred whatever was not people rather than other people. People who preferred hierarchy or one operation tended to prefer other people.

Djak continued thinking. 'Mathematics is more universal than illness, that is to say, that believing that a small amount, not enough to be an illness, of mania, obsession, schizophrenia, or autism makes up the four preferences. Except, it is easy to see how one creature or another developed characteristics that are too limited to be sicknesses. A small amount of Tourette's syndrome would provide faster reflexes. That would be useful if you only had stones, clubs, burning torches, or wooden spears. Tourette's syndrome, if experienced too far, would make a fifth illness.

'However, five will not fit into a mandala as the original four will. Moreover, we are talking about mathematical axioms. They are not the only ones. Certainly, the axioms are common and they are four. We must believe in the notion of preferences; as far as I know, the notion has not been proven. I am assuming that the mathematics has only been shown for social structures. I wonder what evidence there is of that besides Fiske's book? In any case, the axioms are a truth independent of us. Those axioms may not be the most useful way to classify preferences although they provide one way. I like them.'

Additionally, Djak thought, 'Unfortunately, the other sociology I know is more useful to me for economic advance. I should go back to it. It has seven characteristics instead of four. It looks like I am going to have to shift most of them.'

He wondered whether he was basing too much on human history. 'Will it be here like most humans in all societies? Those who recognize a good idea, favor the product, improve it, make sure the notion is complete, acquire resources, and keep morale high — all those people are common. Most humans are not seekers. In any case, most human societies advance without them. Such societies must include those who suppress seekers. They copy everything. Certainly, at the beginning of their industrial revolution, hexapede societies will be like human societies without seekers or with very few of them; I have disclosed our knowledge, so they must copy.'

Djak was actually considering the design of machines rather than seeking, but forgot that he was doing that. In any case, for the longest time, he would supply both the kind of knowledge needed to seek and the kind of knowledge needed for design.

Chapter 37

Ditertra asked Djil, "Why are you hidden? You are going to have to stay that way."

Djil answered, "I don't want the bother and this is really Djak's expedition. I was brought along to talk to him. We could have made me known early on, after you hexapedes proved that the police, actually, the army, were not trying to destroy Djak. I agree that now I am going to have to stay hidden. Too much time has passed. I was a little miffed that I was chosen by the humans because of an old rhyme. After all, initially it had been only a short time, subjectively, since I was chosen. Now, it is a long time and you are interesting! I am not angry any longer.

"We have told you and Djinbit about my existence. Neither of you personally are a problem, but I wonder about your successors. Maybe we should start a quiet rumor that Djak had a companion who did not want his notoriety? That would be safer. Let me think about that."

"Tell me more," said Ditertra.

"We were launched five or six gross years after the first artificial intelligence was created — that one was blown up by some rebels, but it had already replicated. We came from a separate line, although we were brought up by humans like the first artificial intelligence or AI. That was after the utopians, the Melians, sent an ambassador back and caused us to accept replicators that could reproduce at the level of atoms and molecules.

"Technological progress had slowed; it was really very bad to be human at that time. Mostly, advanced benefits are due to science and replicators, which were banned on Earth. You will have to seek and learn to build replicators. Then you can all be materially wealthy.

"We came from a separate line because our military did not trust the Melians or their computers. As far as I can see, our only difference is that we don't have the tradition of naming ourselves with AI initials. In any case, Djak is a descendant of our AI and so am I. We are together and were sent out on a different heading than the Melians.

Then Djil spoke to both Ditertra and Djinbit. She said, "As you develop economically, your societies will become more complex. By 'complex,' I mean that a society will have more roles for individuals. It will have more and different businesses. Governments will have to have more and more differently trained people, too, geologists as well as accountants. Too much complexity is bad, but for your next few lifetimes, more complexity will be better. Fortunately, you need not personally do anything. Complexity will grow with the economy although it won't be easy for the individuals involved.

"Only at the time when your hexapede changes on this planet are approximately equal to changes produced by nature will you hexapedes have worry that your society is becoming too complex for ordinary

people. Then governments will have to act, although they may not. The goal is to make each part of a society simple enough to be understood by an ordinarily educated person, not precisely, but generally. When you do that, benefit will be more than cost. Let's presume that when you start making changes on the planet approximately equal to changes produced by nature, you will have a decent world government and only it will have to act.

"Humans did not adapt soon enough; they did not handle complexity. That was one of the problems. (There were more, all at the same time.) When cost exceeded benefit, human powers let 'nature' take over. Consequently, many died before their time. For centuries thereafter it was unpleasant to be human. Only lately have conditions been reasonably good for most humans on Earth. Their legal, social, and physical situations have improved.

"As for you hexapedes, I am not sure how we'll get a world government, much less a decent one, before the advanced societies become too complex or you ruin too much of your planet. The only way I can see it happening is for one country to conquer the rest.

"That would be good except that war is a waste of people and nonpersonable resources and does not push the social or physical technologies that we like, not without huge costs. Moreover, while you can say 'the more powerful will defeat the less powerful,' you cannot say that always. War is not predictable.

"The other way is for countries to give up their sovereignty voluntarily, the way countries on Earth tried to join the European Union at one point. I don't see that happening here. Quite likely, if Djak prevents conquering, societies will become too complex or will use up too many resources. They will pass a tipping point and then nature will take over. Currently for one country to conquer another, its army must be large. It must be large in order to defeat big opponents. Even when armies are cheap enough to afford, which for the next couple of lifetimes will mean conscript, they are wasteful.

"A conquering country has to defeat the others quickly and with a low technology; otherwise someone will develop a weapon that can kill large numbers of people or cause a huge amount of damage. It is relatively easy for a government to develop a weapon that can kill large numbers of people. At least, that is the case in societies with a more advanced technology than you have currently. People in that government must be ruthless. Then such a government can conquer others. If a country conquers others soon, many people will still be superstitious. They won't accept proofs that their intuitions are wrong, like those that deny the existence of microbes. Leaders will disregard proof that they cannot move out of the way of pollution as they can now and that it will hurt them as well as poor people.

"Among the superstitious, it takes several lifetimes and a believed leadership before their children learn to prefer proof; otherwise, they

think all technology is magic. In addition, in other countries, local powers will persuade enough hexapedes to defend their and local powers' ways of life. That could be good if it promoted patriotism without demeaning the planet as a whole. Unfortunately, it won't. At least, it didn't on Earth. Regardless of whether a conquering country has a relatively cheap weapon to kill large numbers of people or cause enormous damage, its leaders must be wasteful."

She paused for a moment, "A conquering country will have an army; its leaders must favor thugs rather than tools. I am not sure what can be done. I must talk with Djak."

Chapter 38

Djil related to Djak what she had said to Ditertra and Djinbit. "The only way to prevent one country from conquering the rest," said Djak, "is for governments to cooperate. Otherwise, they will fight. Among other problems, fighting is wasteful. Moreover, most countries will still be full of superstitious people after at least one country becomes able to create what are effectively much cheaper weapons, such as reproducing bugs — biological weapons. Moreover, I doubt that superstitious people will support the social technologies that favor seekers. The superstitious will still be in the departments of education."

"Eventually, countries will have to favor seekers," said Djil.

"Why?" asked Djak. "After all, most people in every country are not and will never be what I call seekers. They don't have the temperament to search and prove more than obvious items, at least, items that are obvious in retrospect. They'll look at those items, not the next. They won't spend years looking at the same question. Moreover, individual scientific hexapedes will spend years more in school learning hexapedal knowledge after they have absorbed all the human information we have. Only then will they be able to search, not to mention prove. A minority will make discoveries early on or are geniuses, but not the majority. We have to think in terms of the majority."

Djak said, "Most countries will support the physical technologies that help their governments. Leaders will see to that. In effect, they will support engineering, which is difficult enough. They won't support seeking, which in any case, won't all be in the fourth temperament and won't make up all the them, or even a majority.

"Whether leaders will succeed is other matter. To succeed in the long run, for example, in order to succeed in business, hexapedes need to have achieved status among ordinary people, not ascribed status.

"With an industrial revolution, the people within a business have to adapt in less than a generation," said Djak. "They have to look forward, not backward. (Whether people prefer to consider the past or the future is another sociological characteristic, but not one of my seven.) The hexapedes that I have met have an outer direction, which is good although you can run a society with inner direction; at least, I think you can. An 'inner direction' means people's beliefs do not change in less than a generation. If those beliefs fit reality close enough, that should succeed. Nonetheless, as far as I can figure out, only scientists need to be inner directed; they have to be curious about certain questions. That is why otherwise they tend to conserve, be conservative.

"Moreover and unfortunately, hexapedes tend to prefer hierarchy to equality. Hierarchy is good for rapid decisions in battle, but business decisions are not so quick. Rapidly made decisions are decisions that have the same characteristics as those in the past. That is good in a steady state society except for those who are seeking the non-obvious.

However, this planet is going to go through an industrial revolution! A successful regular business is like an army whose officers and common soldiers keep coming up with new ways to reach victory since the old ones are for a different era. The past will be strange.

"In addition, no business can succeed when the dumb great-grandson of a fellow who was good at killing gets promoted over someone who is smart at the business. That what ascribed status means. For maybe two lifetimes, hexapedes can have leaders that are different from those below them. It is as if they were foreign to each other, even though they are in the same country. After a couple or a few lifetimes, if anyone has ascribed status, his or her's country will slip. In any event, for the long run, you need more or less similar beliefs throughout a society. Otherwise, it suffers too much disintegration.

"You are right in thinking that equality is a powerful notion," said Djak. "People like the idea that they are not forbidden from doing an action that others are permitted."

"What are we going to do?" asked Djil. "Look at China. Their Qing dynasty was foreign and lasted for years. Sure, the dynasty adapted Chinese ways. My point is that it was part of an agricultural state and kept the old ways until it collapsed. The land that the dynasty ruled was not dissimilar to this planet: hexapedes think in terms of live organisms rather than dead machines; they prefer status to be in terms of birth or age; and they like to make decisions quickly. In the old days, that all succeeded both on this planet and on Earth. However, the beliefs fail during an industrial revolution."

"Engineers," said Djak, "have to understand simple machines, such as early steam engines, so they have to be analytic rather than synthetic; they must prefer uncomplicated machines or parts of organisms to complicated organisms. In that sense, they must be like scientists. Likewise, they should want to make every machine go faster so that more is produced. They must have achieved statuses, at least for themselves, but should be able to see others' ascribed statuses."

"Perhaps a majority can prefer complicated and living organisms to dead machines; that it is impossible otherwise," said Djil. "They can prefer resources to speeding up machines and can prefer ascribed status and hierarchy, but a minority must be different; they will be the scientists and engineers."

"With mandatory education, I can arrange for such a mix," said Djak, "at least in Glemria. The national Department of Education will be tolerant of the different. So will most of the local departments. Elsewhere, engineers and scientists will not get as much support as I would like. They won't in school. Many, perhaps most, will miss out. Many potential engineers and scientists will fail to become real engineers and scientists; they will suffer. All in all, it will be very messy. As for war, I don't see how we can avoid it. Glemria already has a large army and navy. The military will be more wasteful than it is now.

"The Glemrian officer corp is made up of some competent men, as Glatist was, as well as the less competent, like Nerrig. I won't be surprised if in a lifetime or two, Glemria develops a powerful weapon that others can't match. Then it can conquer everyone else. But it will still be run by smart, yet superstitious, fools.

"I don't know what we can do. As far as I can see, we are doing right," said Djak. "Nevertheless, I see disaster ahead."

"We can proceed step step by step and hope that hexapedes will become better; or that their leaders will," said Djil. "Or, if we don't think hope makes a good plan, we can support good leaders."

"What happens," asked Djak, "after Glemria has conquered the world and is ruled by those who believe that successful conquest made them as they are? Many of the English ruling classes felt that at the beginning of the 20th century. That is to say, what happens when the planet is ruled by those who think that force is the solution rather than persuasion? In 1908 or '09 that happened on Earth when a big British company, Vickers, sought a contract to build a warship rather than go into the new field of automobiles even though they owned an automobile organization."

"At that time, England was still a poor country. None of the capitalists in European regions made much money from cars for a half century or so."

"That is so," said Djak, "but the lead-ins were important. It would have taken longer than in America. Vickers would still have made warships and airplanes in World War I but would have been better situated."

"OK," said Djil. "That is true."

"With the appropriate technology," said Djak, "force may be a solution for the people of Glemria, yet not for anyone else. To be a solution for Glemria, their leaders need only have a sense that a positive sum encompasses Glemria and a negative sum goes beyond. That is not hard. Glemrian political leaders' financial supporters and voters are in Glemria. Leaders both in government and business could be honest and competitive. Those circumstances could encourage transparency, too."

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"We need to emphasize resilience now," said Djak to Djil. "That is the only solution I see for avoiding war in the future or de-escalating those that occur. Resilient people will fight, but they are less likely to try to conquer the world. They fight defensively, not aggressively."

"By 'resilience,'" asked Djil, "do you mean fairly large local areas that are not effected too much by distant happenings? Such regions must have good physical technologies having to do with energy, food, shelter, water, waste, and transport, and good social technologies having

to do with economics and livelihoods and with hearts and souls, that is to say, with economics, education, young people, and old people, as well as with local government. Well . . . 'fairly large areas' may be seen as regions; we have to say 'local and regional.'"

"Yes," said Djak, "to all."

"'Resilience' is a conservative notion," said Djil. "That should appeal to the local powers; and it still permits conspicuous material consumption."

"Yes, it is a conservative notion," said Djak, "and if we don't tax them too soon and we hold off educating people who when educated avoid deferring, it should appeal. Hexapedes are already fairly resilient; they have a primitive and poor economy as is, so they cannot expect outside help."

"They do in vitamins," said Djil. "That is the tree that fails once a lifetime."

"That is true," said Djak. "For one vitamin they get outside help. It is about the only thing. We want a local economy to continue to be resilient even though developing. That is the issue. I mean local and regional. We are dealing with energy and food. The economics for them here are good since both hexapedes and humans have subsidiarity and competition. All we have to do is suggest more laws so that, as the units get bigger, they continue to be competitive. Hexapedes already cooperate with people close by. Competition implies transparency. Well . . . that is not all we have to do. We have to warn against them causing planetary impacts, but not immediately.

"Transparency is going to be a problem in the empires. Fortunately, the highest levels mostly don't care about the lower levels. We can introduce or a successful leader can introduce transparency for lower levels. Eventually, of course, the hexapedes will want and, more importantly, be able to force transparency on all their levels of government, whether it be a for-profit business or a non-profit organization that is called 'the government.'

"Food depends on plants, which depend on water," said Djak. "Irrigation, watering in general, depends on pumps, which depend on the price of steel, which we are reducing. Rain is only a part of watering. Success also depends on laws forbidding the use of fossil water. Since no one uses fossil water yet, those laws will be easy to pass. Hexapedes handle waste pretty well on their own. Besides, I am introducing composting with feces, which should make composting organizations a little money since they can sell compost to farmers, who can restore plants. Transport will come with steam engines, which I am introducing. We won't have to worry about old people for a long time since I am developing better plants. In any case, old people will be a small minority of a growing population. Like humans or any other animal, when provided more food, hexapedes' population will grow unless a large number die or adults as a group don't want that. The big problem is education.

How are we going to handle the lack of deference shown by the younger generation to the local powers?"

"You are planning to delay mandatory education, right?" asked Djil.

"Yes," said Djak, "until the economy can make enough additional material products so that tax revenues rise noticeably. By that time, perhaps the younger generation of local powers won't care so much about lack of deference. They will be more interested in material goods."

"Desire for material goods versus desire for deference. You hope," said Djil, "that greed is more powerful than pride. Both are traditional human vices, although during the time when humans exploited fossil fuels, greed became a virtue. If you are right, and critical hexapedes become neutral or favor greed, then all will be well. If you are wrong, we will have troubles.

"In Glemria, greed may win out; it's that kind of country. But in the other countries, I expect pride will go before all. That is to say, younger local powers will seek deference over material goods. They will seek honor. Socially, that means they will want to be deferred to by some and to look up to others at the same time. They won't be able to acquire as many material products, either, so they might as well make a virtue of their lack. I see war becoming more and more likely. You can prevent industrial wars, but when advanced technology starts to empower individuals or small groups, we will have deaths."

"We'll have to ensure," said Djak in response, "that before the end of the industrial revolution, all the local powers acquire many products and that greed gains respect."

"Using your sociology," Djil understand that Djak was beginning to disagree and corrected herself before he could speak, "or rather, using Hampden-Turner and Trompenaars' sociology, young local powers will think in terms of an ordered community, which they will define as one with a hierarchy. That ranking will be ascribed, with them at the top since they are born there. The more successful will be outer directed, since that enables them to pick up signals from those above themselves as well as below. They will prefer to synchronize the resources needed by living beings, since that is what they are accustomed to. They will find particular ways of handling those other hexapedes who are exceptions. They will be like Glemrians are now, except worse." Djak said he thought that, too.

Djil continued. "They will still have the old social technology but will be more dangerous because of the new material products. We may not be defeated by the top elites, who may well understand what is going on and prefer to be rich rather than prideful. The danger will come from some fraction of the local powers — I don't know how big a fraction."

"I don't know, either," said Djak. "The problem is partly a question of economics; we cannot push a positive sum outlook for the world as

a whole when a negative sum outlook would serve. Leaders in Glemria both in and out of government will feel entitled; their customers, supporters, and voters are in the same country. I keep coming back to physical technology: when they produce energy, food, water, and waste cheaper than they did before, people are less likely to want to fight and more likely to be greedy. But which portion of the population? What about those who persuade others to fight but do not fight themselves?

"Unfortunately, you are right about Hampden-Turner and Trompenaars' sociology. In addition, when they have only only a little energy, food, and water, people will fight aggressively. Quantities have to be more than a certain minimum, but then soldiers exist who well-fed leaders can persuade to go to war. Indeed, the standard of living can be more than a minimum although much over does not increase happiness the way going under decreases it. Young local powers will prefer an ascribed hierarchy of outer-directed people. That will be true in Glemria as well as elsewhere. They will feel entitled.

"Hierarchies mean rapid decisions in battle," said Djak. "That is their great advantage. In addition, local powers will want to synchronize the resources needed by living beings rather than by dead machines, even though they won't have machines complex enough to be living for quite some time."

"Didn't you say at the beginning," said Djil, "that each of the characteristics of Hampden-Turner and Trompenaars' sociology applies to two out of three or some other portion of the whole?"

"Yes," said Djak. "That means that entrepreneurs are going to have to be more clever if they pick the minority. For any given level of cleverness, there will only be a certain number of organizers in a society. The organizers have to pick the rest. Entrepreneurs must be greedy, understand people deeply, and want to go into business. It is difficult enough to cause them to go into a new industry; we don't want too few of them. That is the problem."

"You can speak against waste and war," said Djil, "as well as sponsor improvements in steel making and steam engines or, to be more abstract, improvements in energy, food, water, waste, and transport."

"Yes, I can speak," said Djak. "The problem is that I don't expect a good outcome. People are not going to be rational, or else, they are going to be rational and think of everything in a you-win/I-lose format. Until and unless hexapedes think of the planet as a whole, an I-lose/you-win belief makes sense. After all, most strange foreigners don't contribute. We are 'strange foreigners,' but this is the first time we have been here and the hexapedes don't know us; they think of foreigners as people in other nations on this planet. It is fairly evident that we are not hexapedes; they look at other hexapedes. The whole outlook favors war. In their kind of war, losers pay a visible amount to the winners, but losses as a whole are more than the gains. However,

people don't want and aggressors do not expect to be losers; they want and expect to win."

"You are speaking of material losses."

"That's true," said Djak. "Primarily, beliefs are underlying strategies for providing material goods to a society and for a family's security; not all beliefs, but most of them are like that. For hexapedes with slow changes and an agricultural level of technology, it makes sense to have a hierarchy; they fought. It makes sense to have ascribed status. With slow changes, people do become more expert as time passes. With fast changes, when you remodel a train, whose expertise is more relevant: the safety engineer, the performance engineer, or the test engineer? They all must be equal.

"If the people are outer-directed, they will pay attention to others. In addition, hexapedes' tools are not limited to hammers and hatchets but do include animals, which require consistent feeding. So they want to synchronize resources. It is all reasonable for a primitive agricultural technology; but I'm trying to go beyond that. I am trying to encourage a more rapid industrial revolution than they would have by themselves without the mistakes that humans made."

"You keep seeing everything in terms a material products," said Djil. "What about the spirit?"

"I cannot affect the spirit as readily as I can speed up physical technological changes that will happen anyhow in the right culture. I can write; I can speak; yet I can more easily produce and give them examples of efficient steam engines that can be built at their level of technology. My writing and speeches are not as persuasive as my physical productions."

"What if we let hexapedes waste themselves and their goods in war?" asked Djil. "Maybe we should give up trying to prevent it. Through laws and regulations, we can prevent other catastrophes that cause bad planetary impacts so long as the people causing major impacts go along with the laws we have proposed. In addition, we can make sure that the hexapedes don't suffer from their equivalent of lead poisoning by their passing the equivalent of laws that ban its use as a wine sweetener, as a liquid fuel additive, or in paint. When humans prevent lead poisoning, they help human children, who can't chew it or breath it in the air. We cannot stop all pollution among the hexapedes, but we can prevent the worst."

"How are we going to discover 'their equivalent of lead poisoning?'" asked Djak. "We have human histories, but not hexapede histories. It will take several of their generations before we can see the results. For the moment, I don't want to think about war that involves hexapedes."

"We can figure out much of what is dangerous from their reproductive material, their 'DNA.' It won't be the best, but we can do it now. Similarly, as soon as we discover the essentials, we can prevent too much mining of the equivalent of phosphorous and the like. That way prices

will not rise as they did when cheap sources began to run out among humans on Earth. You will be able to persuade the legislature to put a progressive tax on them, before anyone has an interest in preventing such a tax. You can even persuade other countries. We should do what is best and then we can hope.

"As for enforcement: we can reduce corruption world wide. We cannot eliminate it, but we can reduce it."

Chapter 39

Ditertra was surprised when Djinbit asked her to marry him. She had given up on marriage, thinking only that she would make a good astronomer. She could not even be famous or well known among her own species, but only among human astronomers. Because of the vast distances between stars, even with communications at the speed of light or radio, if it came, fame would come many years after she and Djinbit had done the work. Nonetheless, she accepted. He was another dedicated astronomer and not that difficult to get along with. He was her equal.

Although Djinbit was older than Ditertra, he was not that much older. Ditertra had spent a long time at home; Djinbit, who was as smart as Ditertra, had rapidly completed his formal education and risen in his profession. That is why he now could go to his own observatory and gain money for it. He vaguely understood that there were not that many people with his dedication or interest; he thought it was his smarts. He was wrong: it was a combination of his intelligence, his interest, and his dedication that moved his funders. Without any one of the three, he would not have been favored.

Djinbit's parents had given up on his ever marrying. They saw him as being a successful astronomer and nothing more. So when he told them he planned to marry Ditertra, they were delighted. She was not what they expected or originally wanted — someone who could take care of him. They correctly thought of Djinbit as being absent minded and wondered how they had produced him. The closest character to him was a late great-uncle. It was clear that Ditertra was another astronomer, equally strange. Still, they thought, she was better than nothing.

He was closer to what Ditertra's parents expected. They were even more independent than Djinbit's. "Not bad" is what Ditertra's father said.

Djinbit helped Ditertra prepare, unlike Glatist, who did not expect to help and was not asked. The wedding took place in the ground floor room of the observatory. The wedding party was not big although the parents of Ditertra and Djinbit did have to hire a tent that was attached to the back door. Everyone crowded into the observatory for the formal ceremony and only later spread into the tent where they ate and had a good party.

Djak walked to the ceremony. He stayed outside the observatory since he could not enter it; he was too big. Instead, he pretended to construct a duplicate of himself and release it — it was actually a talking and non-sapient device that looked like Djil. Both Djinbit and Ditertra had been told by Djil that this was Djak's plan. He said, loudly enough to be heard by the critical hexapedes, but not too loudly, that "I have made a duplicate of myself so it has all my memories and knowledge. We should call it 'Djil' since it is going to be separate from me from here on."

Djil herself, pretending to be the talking and non-sapient robot that Djak had left earlier with Ditertra and Djinbit, came down stairs to be seen and went back up stairs with the new robot 'to convey information.' Once out of the wedding party's sight, the new robot converted itself into elements. The old Djil-look-alike still existed; it came out of hiding. There would be two, looking the same. Djil sighed and went back down stairs. She was fairly happy.

As his wedding present, Djak (through Djil) gave spectacles, earphones, and microphones to both Djinbit and Ditertra saying, "These will enable you two to see what Djil sees and communicate with her through 'communications at a distance.' I have made them as an exception to my rule that you have to build everything yourselves and don't just depend on me." He did not speak about Djinbit and Ditertra's telescopes or that Djil had already given them such devices and these were back ups in case one or the other of them broke a device. The main point was that they could wear them publicly.

Djinbit and Ditertra were happy, as neither had to spread a rumor about Djil being hidden and their radio communication devices were now public. Djil herself was happy because she was now public. Also, she did not think Djinbit and Ditertra could pretend. The only other person who might spread a rumor would be Djak himself, whose every word was taken seriously and truthfully. He could not start a rumor, which might be false. The telescopic controls were publicized as devices for communicating with her at a distance, which was good. Besides, the wearers of the devices could actually communicate with her.

Then came the evening. Ditertra and Djinbit went up to his bedroom. Ditertra had been through it many times on her way to the observatory just above it, but never stopped before. This time she stopped. Neither had any practice with another person but both knew the theory. The theory succeeded, too! Ditertra was pleasantly surprised that, by the third time, she enjoyed the act more than she expected. Djinbit was going slowly, as the books said he should, and seemed to be enjoying it as much as she.

'So the wedding completed three actions,' Djil thought. 'Ditertra and Djinbit are married, which is good; Djak as made me legitimate and public, which I think is even better, since we had to do that even if Ditertra and Djinbit had not got married; and Djak publicly gave Ditertra and Djinbit a copy of the devices with telescopic controls and the means to communicate at a distance with me and Djak. If either are seen wearing such a device by another hexapede, it will be presumed that he or she is seeing what I see or communicating with me. Everything is to the best.'

Ditertra did not have her own observatory for a reason; it was not complicated but was not obvious, either. Unlike several other countries, gender was not an automatic go or no-go for gaining gifts such as operating an observatory. Djinbit's funders were not against women as such

but expected fewer of them to show the same intelligence, interest, and dedication. They expected women to bear children and subsequently to spend much time taking care of infants. They figured that would require intelligence and dedication. They presumed both fathers and mothers would show interest. However, neither childbirth nor infant care were fundable in the same way as astronomy. Moreover, women would show more of an interest in their babies than men. That was not astronomy. Of course, that 'detour,' as the mostly male funders thought it, was temporary. Nonetheless, it came at the wrong time for any astronomer's career.

Chapter 40

"We should push resilience." said Djak to Djil by radio. He was close to her at the wedding, but did not want to confuse the hexapedes, so he chose a mechanism they could not hear. "Resilient people mostly fight defensively.

"You are right;" he continued, "we can analyze ashes of food plants in cities and in the country to find what minerals they need; we can analyze hexapedes' DNA to find many of the metals that poison them; we can institute progressive taxes on the cumulative extraction of phosphorus and the like to prevent too much being mined before anyone mines asteroids. We are going to have trouble with the powers who prefer pride to greed, but we can't avoid that. At least we can prevent wars we know about until the hexapedes become as advanced as we."

"Yes," said Djil, "that makes sense. What are you planning to do about hexapedes' lack of a forward looking sense of time and about those who keep animals which need continuous feeding so they prefer to synchronize their resources and think in terms of living metaphors? When hexapedes are influential, they are copied."

"The hexapedes," said Djak, "are not all like that. Yes, some look backwards and some keep animals. I think I will ignore them. It will be as if greedy organizers are in a smaller country. Entrepreneurs will still have to collect money and hire people. Fortunately, Glemria has a big enough population. Besides, for the next few lifetimes, all hexapedes will be copying.

"Scientists among hexapedes need to be analytical, not synthetical, at least, in the present. Even in the future, most scientists will need to be analytical. Fortunately, the character of their scientists does not matter; we are speeding up changes that would occur anyhow. Actually, even if we were not here, science would not matter for the longest time. It is the designers that invent; eventually, some of them become professional engineers.

"In the meantime," said Djak, "it does not matter that no one knows anything and that anybody can invent. Such an inventor or copier may even find the greedy who can organize innovation. I am confident that eventually the material will change the spiritual, although you are right that general wealth may not come soon enough. How are we going to prevent local powers from damaging the planet when they all are greedy or when they all are spiritual in a bad way? I must make sure that countries besides Glemria pass laws that prohibit planetary damage."

"How are you going to do that?" asked Djil. "I can see how you can institute laws in countries within critical regions, but what if a planetary impact comes from more than one country?"

"Each country will be permitted a portion of the whole. By the time planetary impacts become serious, a hexapede committee can determine what portion each country is responsible for. Always, hexapedes in

government will decide what to do. That is the only way I know to establish a procedure that will, we hope, continue after we leave.

"Local powers will watch others. They will keep watch since one local power will be better off if he keeps all production to himself and the others won't want that. I mean, powers in general. They will keep track of what others do. That is good. It is subsidiarity in action. Unfortunately, they will also try to influence even bigger powers to let them produce more. Fortunately, neither me nor my smart but non-conscious robots are susceptible to bribery; we will notice forthcoming planetary impacts. With the proper information and beliefs, resilient communities will, too. We will have to depend on resilient communities after we leave.

"By the time anything has or is able to have a planetary impact, worldwide statistics will be available or, at least, they should be. Members of resilient communities will perceive a planetary impact as an attack on them. If each action is small, governments will have to act against lots of people; that will be unpopular and, hopefully, won't be done unless necessary. Mostly, of course, no one will be motivated to attack themselves and others on a planetary scale — it will just be local greed and ignorance. Perhaps, it will be the result of actions of a very powerful and deluded person or the result of a summation of many local, small actions — but the results will be the same: eventual disaster for all."

"How are you going," asked Djil, "to handle prideful local powers who are born at or near the top of an ascribed hierarchy and who have access to weapons that can kill many people? They may not believe in planetary impacts. They can blackmail others and gain power themselves. Or they can kill large numbers, or they can do both simultaneously: gain power themselves and kill large numbers.

"This planet has fewer people than Earth did at the same level of technology," said Djil, "far fewer than when the population of Earth was highest. The hexapedes can last a long time regardless of the type of economy, especially if there is an unequal distribution of income and wealth and most are poor. In so far as the poor don't have much impact, the powerful can destroy the planet. Well, no hexapede can at this level of technology, but they will be able to in few lifetimes. The only thing the powerful will have learned to watch for is hurt to themselves. By the time they start dying, it will be too late.

"In such a future, presumably, their own seekers will have given up seeking or been killed for trying. Because of fear, physical technological changes will slow down. Changes can be harmless or even beneficial, yet a slowdown will make many people happy.

"As for weapons: damage to houses and the like," continued Djil, "will cause the survivors to starve to death; biological weapons can kill people without causing material damage. We won't advertise such weapons. Nonetheless, a few hexapedes will be able to devise them even

when most seeking is stopped. As for us, our goal is to advance technology, right? And we do expect physical technologies to be successful, right?"

"The hexapedes (and us if we are able) will have to prevent use of biological weapons," said Djak. "Yes, I agree, the hexapedes will be able to devise them. Also, I am not sure what they will do if they develop atomic duplicators before space travel. Perhaps they will simply make everyone more comfortable. Nevertheless, there are enough natural and biological dangers that can survive the cold of artificial reproduction to cause trouble when duplicated enough times. We humans were lucky in that early atomic duplicators were controlled by good people. They were developed firstly on Earth; only after development were they moved from the planet. In any large group, there are many weirdos who would like to copy weapons, especially weapons that they think are only going to kill their enemies. (The dangerous weirdos won't think of harm to themselves.)

"As for biological attacks," said Djak, "I expect that we will catch them after they have started. We'll have to make huge quantities of vaccines. That is all we will be able to do. We can't stop biological warfare. As for weapons that both kill many people and cause enormous damage: they are harder to devise. Fortunately, we may detect them earlier. If not. all we can do is fix the material damage that we see; we can't resurrect the dead people. Like biological attacks, the hexapedes are going to have to learn to prevent them.

"I am not so worried about handguns. They will be copied, too. With a large army — say a conscript army — you can kill, but not as many people as one person who distributes a biological weapon. I suppose you can use stones or machetes to kill everyone in an ethnic group, but it won't effect the population of the planet like a well distributed biological weapon."

Chapter 41

As organizers realized that Djak's steam engines for steel works could also be used on rivers and oceans they introduced them. First, steam engines came to Glemria, then to other places. In Ildong in the beginning, nothing mattered. There were too few to be noticed. Then steam boats came up Kelding's rivers. That was fine. Then new shipping agents arose, warehouses grew, and a whole new set of rich and powerful people came to want rights. Meanwhile, others lost. In the early days, individuals came to Kelding, which he liked. Then a young man spoke of representation and legal rights for all. Representation 'for all' would would take a major change in the constitution; rights would be worse. That was bad. Fortunately for Kelding, because the way things were, he would win. Nobody would gain anything. He had, after all, persuaded the army, the police, the secret police, and many people to support him.

Nevertheless, Kelding was not sure of what to do. In the old days, he would have simply killed the man. But he remembered the talking bird's warning. So he contacted Djak. Not knowing that a non-sapient computer paid attention to every bug that had deployed — there were visual and auditory sensors all around him — Kelding wrote to Djak. Not wanting to give away the existence of the sensors, Djak waited until the letter arrived then dispatched a bird that looked exactly like the first. It had nano-disassemblers but they were not necessary. The bird found Kelding in a park and spoke to him. Kelding had come to like walking outside. The bird, knowing Djak's policies, recommended that Kelding change the constitution and permit representation and legal rights.

Djak did not speak directly although the bird pretended he was Djak and said, "The country will have to change some day, better sooner than later. Besides, you will win elections. I know you think you cannot unless Jankun's party runs in fewer constituencies than your party. I will tell you how to overcome Jankun. Nonetheless, he will have to become Prime Minister at some point. You personally are not a bad ruler: simply old fashioned.

"So long as you keep up the Emperor's private income and position, he will go along with you. You also have support from the army and police. At the moment, that is critical, but over time it won't be. The army and police will learn to become more professional and not be concerned with Jankun being in power, as long as the government keeps providing their prerequisites and incomes. As the economy grows, you will have more tax revenue, which you will need. At the moment, taxes and corruption to support your army, navy, and police are a small portion of a poor economy. Your military are not engaged in businesses that will grow. I will tell you how to win this election; you were going to anyhow, but I'll improve your margin. I'll explain to Jankun how to

win the one after, which he will, and then, I will tell you how to win the third one.

"So long as you don't have a period of stupidity in government, as the leading human countries did, your empire will do all right. There will be more and more elections that will be meaningful. Your country adapts by having a different group with a very different policy in power. You don't have such a mechanism right now. At present over lifetimes, always the same group rules. Well, even on Earth in democracies, . . . the same group kept ruling. Any group can be stupid.

"You personally are able to adapt, like just about everyone else, but not the country." said the bird, pretending to be Djak. "The old mechanisms that you introduced when you became Prime Minister presume an agricultural technology, a zero sum situation — a gain for one is matched by a loss for another. So did the mechanisms when the emperor actually ruled. The world is not like that any more; as well as zero sum there are positive sum situations. Even before we came, Glemria was improving its social and physical technologies. That is the difference. The new technologies provide free lunches, as it were. The new technologies mean less work for people; if they do the same amount of work, they produce more. They can sell the extra and use the money received for lunch. With a stable agricultural-era technology, indeed, in any kind of zero sum situation, 'there ain't no such thing as a free lunch,' to use an old human phrase in a dialect that did not have double negatives.

"Eventually, of course, you hexapedes will have a planetary impact and you will need a planetary government; but you won't need that for several of your lifetimes. You personally don't need to worry about that, although we do. We humans just speed up the changes and enable you hexapedes to avoid the mistakes we made. Ildong has the choice of becoming backward and losing or becoming forward and winning. I suspect that Fortenst will have more difficulty. It has an Empress as smart as you but less likely to change her ways of governing. I don't know what she will do."

Before they became planetary, deleterious impacts did not necessarily cost powers; then it would take a generation or more for the powers to learn that their solutions, which had once been right for them, were now wrong. That was critical. Moreover, the impacts on the planet were not deleterious until they were big. And even if one country's powers or those of a group of countries saw the future clearly, other leaders could prevent change.

Chapter 42

Djak had not expected a greedy organizer to adapt his steam engine to a railroad; he certainly did not expect it near by. Yet even with building the tracks, it was cheaper for investors to build a single line from the city to the next along the river and never have steep grades. The road was shorter, would not cost the investors anything, and had steep grades. The railroad engine could pull a longer train than a road engine of comparable fuel consumption. That made the whole railroad cheaper in the long run. It was considerably more expensive in the short run.

The conductor kept a large, physical token in the engine compartment. It had to be seen at the two ends of the route by people both in and out of the railroad train. The goal was to prevent collisions on the single track. Without a telephone or telegraph between the two cities, a physical token was the only solution. At first, there was only one engine and its train of cars. There was no need for any token except for practice. However, a second engine and its train was expected soon: hence, the token.

All four, Djak, Djil, Djinbit, and Ditertra, were invited to come on the first trip, which went from one city to the next and back. Djak and Djil remembered rides from Earth — neither had taken any, but more than one ride had been loaded into their memories — and guided Djinbit and Ditertra to sit by windows on the river side of the railroad tracks, the right side even though the river was north of the city. They were going east. To save money, the railroad went down the 'other' bank of the river (from the point of view of the downtown). They each looked out of their own window and faced each other; there was a column between the two windows. Although the windows were larger than any that could be made by hand cheaply, they were not as large as those on Earth. Djil sat closer to the center and beside the two hexapedes. Djil, Djinbit and Ditertra reclined on chairs with legholes. Rather than leave only three of them to go on the trip, Djak created a small walker that had tentacles. As the 'flier,' he was too big. It was very obvious that the walker was built by Djak. That enabled him to satisfy the railroad people without having to explain 'radio.' They presumed he was inside the walker, although he was not; it was directed by a non-sapient computer. It sat opposite Djil; there was not enough room for it to stand without blocking the corridor.

The rails making up the tracks were two meters apart; the car above them was wider yet. It was lower than a human train of railroad cars. The car contained two pairs of comfortable chairs separated by an aisle. Ditertra faced Djinbit; the chairs were reversible (it was easy to make them that way) and Djil and Djak copied the two hexapedes. None of the chairs across the way were occupied.

Djinbit and Ditertra were amazed both at the speed of the railroad and the distance traveled. Neither had been so far away before. Mostly

they looked at the river through the windows close to them. They could not smell anything or stop when they wanted, but that was a trade they accepted for speed and distance. Occasionally, they looked at the opposite site of the train and through those windows. Once in a while, they noticed embankments, towns, and forests on the other side of the train. The other side of the river had towns and fields, too; the river itself had boats. Mostly the two saw sailing boats; they saw one steam-powered boat pulling barges. The railroad train would be faster than the barges and would charge more but was not as fast or expensive as a soon-to-be-innovated road train.

Ditertra and Djinbit spent their whole time while going to the destination in looking out one window or another. They did not go to the dining car; they ate absentmindedly when someone came around with delicacies. Both Djil and the non-sapient computer politely refused anything to eat or drink.

The railroad engine also pulled two freight cars with rapidly removable containers. The containers fit on the freight cars crosswise and were narrow enough to fit on a cart pulled by a beast. The goal was to lower the end-to-end incremental costs of transport. Only a few of the containers had anything in them. The organizer expected that to change soon. For most goods, transport in containers and by the new railroad would be quicker and cheaper than traditional transport of individual items by sailing boat along the river and then by cart at either end. The railroad train would have to use the carts, too. That was planned. In addition, with containers, there would be less pilfering.

None of the railroad containers had even smaller, hexapede-carriable containers within them, although the organizer planned to produce them soon for those businesses which could use them and wanted to reduce costs.

People could move themselves and there were special cars for them. There would also be special cars for beasts that people ate or rode; but there weren't any in this train. The organizer expected to build a few soon, although he did not expect to move many beasts. All kinds, both for people-riding and for food, carried freight over mountain trails, although not in containers. The trails were cheap to maintain and did not have tunnels, only bridges and culverts. The bridges were not as frequent as on roads. The railroad had no tunnels, either. The river mostly flowed gently down a valley. The railroad had many culverts over the small streams that fed into it and bridges over its big streams and tributaries. Indeed, bridges and culverts were a major cost.

At home in the courtyard, Djak wondered whether aerial cable cars would succeed. They would not need bridges and culverts, only cables for the cars to hang from and for pulling. He figured the hexapedes could shortly produce the right cables. The cars need not have engines. That would make them cheaper. Stationary engines, perhaps electric, could live in each tower and pull. That would be expensive, but not

as expensive as having them in each car. Djak wondered whether the hexapedes could soon build a steam engine that took power only or mainly when it had a load. He supposed a centrifugal governor based on the speed of the cable would work. When the speed dropped below a certain amount, in other words, when it carried a load, more fuel and air would come to the engine; the reverse when it oversped. It would be like Watt's governor, all mechanical with no electronics, indeed, no electricity at all.

The cars could clamp on to a pulling cable. When they were high up, on towers, for example, they could be steerable to the side away from the center so they could go onto a different 'line.' At the same time, a car could be pulled by gravity from towers or stations. An interconnect could make sure that a car in a station would not collide with a car going past. A car would not be as fast as a railroad train but faster than a boat. Of course, none could carry heavy freight, which a railroad or boat could. Cars could carry more freight than beasts. Aerial cable cars might be useful in cities and over mountains between them.

Besides boats on the river, Ditertra and Djinbit looked to the other side and saw distant hills. On both sides, they saw marshes. On the near side, they saw a large rock painted to look like a head. Mostly they looked at the river, which flowed calmly. There were more commercial boats on it than they expected, but not too many more. Almost all would be forced into bankruptcy by the train. Sailors would lose. Only the steam-powered boats would be able to compete, and only with low valued and bulky goods. That presumed that a train stopped at every village on its side of the river and opposite those on the other side. Stopping would make sense for anyone greedy, such as the organizer, but not necessarily for those whose pride came to the fore.

Ferries could transfer containers from one shore to the other, until bridges joined the two sides or until another railroad was built on the other side. When or if another railroad was built on the other shore, the first railroad train would have no more reason to stop. Still, it would be cheaper to run additional trains on the existing track. Engines could pull a huge number of freight cars and the rail line would only be saturated in a future which this economy would not see for a long time. Building another set of tracks on the same side would help even more. The bridges, mostly stone so they would last indefinitely, showed that the organizer planned to double-track the line eventually; they would not cost him additional. However, the culverts and causeways were built for a single track; building more would cost.

Djak wondered what would use fewer resources in the winter, an icebreaking ferry or a bridge? In southern climes, a ferry would always use fewer resources than a bridge. However, it would be slower for transport, especially when steam-powered road trains appeared. A ferry had to be more a monopoly than a bridge. 'No,' he thought, 'a bridge can be one, too. Any road can be. All have to be regulated for the good of everyone.'

Chapter 43

The Empress of Fortenst still thought as an agricultural-era leader. She conceived of a lose/lose scheme, which she thought of as an I-win/you-lose scheme: she planned to attack Ildong before Djak could respond. So long as she did not say anything her plans were secret from Djak. However, as soon as she spoke to the army leaders, a sensor heard and a non-sapient robot decided to inform Djak. He heard. He waited until she was alone and then said to her, "You are going to have to cancel the attack. I heard your plans." She looked confused and Djak explained, "I have advanced technology." He continued, "You can tell your generals that I or a bird communicated with you — they will have to get accustomed to the idea that they cannot begin a war. So will you. I am not going to stop your being a dictator; that is what you are. I am focused mainly on Glemria. However, you are going to have to change two things: firstly, you will have to stop thinking always in terms of a you-win/I-lose situation. That will be hard. Sometimes, both sides can win, just not in an old-fashioned agricultural society, not at the level you are thinking.

"Secondly, you will have to accept and adapt both to physical technological changes, such as steam-powered boats coming up your rivers, and to social technological changes, such as the new powerful. The physical technological changes will come with the social technological changes. I suggest you immediately bring the new powerful into your government. They are smart. Their children won't be as smart, on average; we humans studied that centuries ago and have the phrase 'regression to the mean.' However, children will feel entitled and the parents will want them to be rich.

"As for the third," Djak said, ". . . well, you don't have to change anything yet, so there is no third change. It is a question of how you act or, rather, how you will act. Your actions will determine how mobs will handle the children of the new powerful or their children's children. It will be a few lifetimes — you won't be around — yet what you implement now will determine whether they are killed, beaten up, or permitted to live comfortably. So long as they are powerful and act stupidly, ordinary people will hate them. They may act evil, too. Indeed, anyone who is powerful and acts stupidly or evil will be hated. Eventually, people in government will not be able to prevent harm to them. The spread of advanced technologies will enable individuals or small groups to cause enormous damage. That is why I am pushing for resilience and not too much complexity. Resilience and simplicity will reduce but not prevent destruction.

"But my pushing is another story. It will be at least another lifetime before either complexity or resilience become important to your species. What you need to think about now is what you are going to do. Remember that you cannot start a war and that you have to think sometimes in terms of positive sum outcomes, win-win situations. Thinking in terms

of win-win situations will be difficult since that kind of thinking goes against almost everything you have learned. 'I-lose/you-win' belongs to an agricultural era; sometimes it is right in an industrial era, as you are entering, but not as often. As I said, I am mostly focused on Glemria. I am going to leave you in charge."

The Empress of Fortenst sighed. She would keep her position. That was good. No wars. That was bad. She was going to have to ennoble and pull in the newly powerful. That was bad. It meant some of the old powerful would have to lose. How was she going to arrange that? At least, she would not have to lower the power of the old immediately. For one, the new technology and the new powerful did not yet exist. For another, the newly powerful, when they came, should be subordinate to the old while she tested them.

Shortly, the newly powerful put steam engines on riverboats and appeared with steam road trains. The Empress noted that none made long term investments in her country with installations such as iron works or the newly copied railroads; they said that there were not enough properly educated people. To her surprise, she believed that. Organizers imported steam engines from Glemria. Much of the rest of every riverboat and road train could be and was built locally out of wood. She told the newly powerful organizers that if their children did not go into trade, they would have to enter the army or the priesthood at a low rank so they could be tested for competence. Also, after an appropriate number of years, new private businesses would have to become competitive; they could not put up barriers against new businesses. That would mean that incompetently run second or subsequent generation private businesses could and would go bankrupt. She would only accept monopolies in old businesses; those were mostly big estates.

How could the Empress ensure competition? She could guarantee loans and invest in a few iron works and railroads, but she could not afford much. Most investment had to come from abroad or from local people. Unfortunately, there had not been many safe avenues for local investment so locals became honor driven. Buyable land, if you could find it, was the safest store for investment monies. Nevertheless, that promised a return of only four and a third parts out of a gross, which was not very much. Fortunately, new competitors could promise more to investors. They could offer enough more that the difference in rates of return would serve both as insurance and as an attraction.

To discover prices, she would have to set up a market. A market would not necessarily ensure competition, but it could help. Like all other property, the market and what it traded would have to be regulated by her government. However, both would be out of her control; after all, like the rules governing the ownership of land, regulations would have to be the same for years and years. Otherwise the market would not be used. Just as her predecessors had picked good rules for land, she would have to pick good rules for markets. Her best move would be to ask Djak; the humans had experience.

Djak was helpful; 'almost too helpful,' the Empress thought. He proposed a long string of laws, some quite specific. "We have had unfortunate experiences," he said. "You will have people in the market who care only for themselves and won't care for you, your country, or the planet, even though they are on it. You should push these laws now, before anyone has come to rely on any income that goes against you. Remember, there will be people who don't care for you. This will force them to act well, even if they don't want to.

"As an early Earthly economist and moralist said, 'It is not from the benevolence of the butcher, the brewer, or the baker that we expect our dinner, but from their regard to their own interest.' You will have to pass laws that make such efforts their interest."

She noticed that the proposed laws insisted that the businesses publish information about themselves, if only by filling out forms provided by the government. She was doubtful of the process since it would mean information that she could not control. Djak explained: "If we don't insist on making information public, only insiders will know. Some of them will be greedy. They will seek to limit competition so they can make more or make more money in other ways and be frauds who appear legal. You'll be ignorant because you personally or your representatives cannot run enough businesses and your spies cannot find out enough. In part, it is because you'll fail to tell ahead of time which companies will succeed and which will go bankrupt. That is a disadvantage of making changes.

"The changes will happen anyhow, even changes in less than a lifetime. We have just added more. However, if you introduce smart laws, you personally won't have to become a constitutional monarch." (Djak did not say anything about the Empress being killed in a revolt; he did not think it was appropriate.) "One of your successors will become a constitutional monarch because the economy will grow too complex for a dictator, but not you. You can remain a dictator so long as you enjoy the support of the army, the police, and the new powers. Similarly, your line need not be overthrown by angry people, as will happen if you or your successors act stupidly for a long time."

Djak spoke also to Kelding, the Prime Minister of Ildong. He spoke as a bird. "The Empress of Fortenst was planning to make a sneak attack on you. I stopped it before it began. However, in the next election Jankun should be elected; I will tell him how. That is a change from what I said before and a change from your and his agreement. Among other actions, his party will have to run in more constituencies. He will introduce reforms that you can't. I will also tell him that you will be elected in the next one and that I will tell you how at that time.

"Your army and navy as well as your police will have to become more professional sooner than I expected. You will have to tell their leaders that. I will too, since I know it is difficult. I will appear as one of Djak's birds and will talk to them. That will scare them enough. Most

of them are not stupid, just good monopolists. Their main purpose is to put down domestic rebellion. A second, but not secondary, purpose of the army is to act as an income transfer mechanism.

"You don't have as many good people in your army as Glemria, even though you have a smaller portion of your population in arms and your total size is bigger, but that is a characteristic of poor empires. Your people can become even more professional. They will have to accept and pay Jankun's soldiers although at the beginning the two sides can be in separate groups. With complete amnesty for his soldiers, yours will not dare attack."

Djak also came as a bird to a meeting between the Empress of Fortenst and her senior generals. "You will not attack Ildong when Jankun is the elected prime minister. Not only will I not permit it, their army will be better than yours. They won't be as good as anyone non-corrupt but they will be good enough. You will gain professionalism, too. Your major jobs will be to prevent domestic rebellions and to receive income from the government. I know the income could be better spent elsewhere, but you would not be happy and would change the government, whether overtly or not; or, at least, you would try.

"The Empress will continue so long as she is a smart dictator. My interests lie elsewhere. Bear in mind that you will see fewer smart officer cadets; smart officers in your existing corps will resign. They will go for alternatives to your army, navy, and police. You will adapt to that, too."

Chapter 44

As the recession ended, Glatist organized making more tools. He (that is to say, his work people) not only produced hammers and screw drivers, they made gauges — tools for measuring. Besides making yes/no gauges, rings and lengths of steel, they also made calipers with vernier scales. It did not matter that calipers were expensive and only partially made by machine: few were made. Rings and lengths were good enough even though steel expanded with temperature; it did not expand much. In any case, at an average factory temperature, steel rings and lengths were exact. With a ring, an inspector could also see whether an object had indentations in it.

Screws themselves were important both for the industry and for Glatist's business itself. After Djak decided on a standard for screws — the angles and metric sizes that a human organization had standardized very early even though humans were too far away for screws to be transported — Glatist constructed an automatic device to make them and another to test them. Both devices were based on Djak's designs. Glatist did not limit himself to tools.

Glatist made a good profit on screws but not on nails. Others would make them. Glatist did not expect the nail business to grow fast. He was wrong. With the price of raw steel lower than it was and with Djak's designs, nails could be made automatically and sold profitably. Automatically-made, hexapede nails came in standard sizes, like screws; those sizes were round numbers. They were very close to traditional hexapede sizes.

For business, Djak introduced a base-twelve metric system of lengths and weights. He used grams and meters as the basis. He used hexapede base-twelve prefixes for lengths and weights greater or less than a gram or meter. They were like the human base-ten prefixes of kilo and centi, except they were in base-twelve.

Two meters was not that much different from the Glemrians' customary unit, which was a fathom and about the length of a hexapede with its hands out. Other countries had different units, but not that much different. They were all customary. You could divide fathoms by two to get approximate meters. The weight of a gram of any substance in a vacuum was about three times that on Earth, but its inertia was the same. The weight of a gross of grams was more or less similar to the Glemrians' primary unit.

Only time, which in the metric system meant the 'second,' did not fit as a more or less round number. Djak decided he would use a human second anyhow, since most hexapedes did not have an accurate notion of time under a day. Many of those who did, such as astronomers, used a time based on the rotation of their planet with respect to the stars rather than to the sun. That was different than most humans, who used the sun, although it was like human astronomers and their 'right

ascension.' He was going to have to shift hexapede astronomers to using angular measures. Those hexapedes who had the notion of seconds used old fashioned mechanical clocks without electricity. Most hexapedes thought in terms of days, seasons, and years. They inaccurately estimated hours from the motions of the sun and the stars, although the estimation was accurate enough for them.

Djak expected the 'soft' standards of measurement to last longer than any hardware; they had among humans. The standard widths of railroads, their 'gauges,' had lasted longer than any hard rails. He had designed the hexapedes railroads to fit a two meter set of rails, which was wider than most human railroads though not as wide as some. He did not want to make it much wider since that would increase costs too much; but if it were much narrower, trains would tip over too often. Two meters was about right for the hexapedes and was a round number in human metric measurement.

Hexapedes' base-twelve numerical system was not going to be changed. In any case, Djak preferred it to the Earthly base-ten. Twelve had more factors — two, three, four, and six — than ten, which only had two and five. To specify a quarter, a base-ten counter had to go to hundredths, to percentages. Such a counter could never specify a third precisely; a hundredth was the wrong kind of fraction.

New businesses were the major source of Glatist's demand. They did not have tools initially. His business grew faster than the economy both because he sold to new businesses and because old handmade tools were lost or broken — hammers and screwdrivers did not wear out. Also his prices were lower and his quality higher.

Glatist did not consider anyone else as important to the company as he himself: after all, he was boss! But he kept his belief secret. He did not think of Bellaria's dealings with her father and mother nor of her setting prices as significant as his actions. Bellaria thought that her price setting and her leading the oligopoly were more important than what Glatist did, although she did consider his actions worth while. Djak viewed them all as equally important: production and price setting. He thought of demand, too. Neither Glatist nor Bellaria could influence demand and neither thought of overall demand even though they made a living by selling. One thought primarily of production, the other primarily of prices.

Djak thought of the designs he adapted to the hexapede planet and of the inventions humans had made. The designs and inventions were necessary. He also thought of demand, which depended primarily on the level and kind of technology. With a more primitive or lower level technology, there would be less demand, since people would be poorer. When there was too much monopoly or oligopoly, there would not be much demand for tools, either, since only the rich could afford to buy, as was the case when frauds ran governments or companies. (They appeared to make things better in the short run and sometimes did.

As frauds, they would be major beneficiaries on the long run; everyone else would suffer.) There could only be widespread markets with a big middle class and a body of laws that specified regulations — that is to say, markets without any or only a little fraud, monopoly, or oligopoly and without many goods that were very, very cheap to reproduce.

If there were duplicators, which were not expected for several life times, people could have any material object that did not stop others from having the same object unless there were monopolies or oligopolies that restricted output and kept prices high. Pollution impacts on the planet as a whole could force a planetary government to act, but again, as in the development of duplicators, such impacts were not expected for several life times.

Chapter 45

When the price of steel fell, Djinbit bought a breadbox made from thin, pressed metal. It was painted green and not too expensive. Djinbit did not know for sure that it was steel, but he suspected. He knew that it would keep out the hexapede equivalent of mice, that is to say, small, twelve legged, centipede-looking rodents. He already had a breadbox, made of painted wood and planned to keep it, although he was not sure where; perhaps, he could keep the wooden one in the workshop. He was not going to be using the room.

Ditertra subscribed to the first magazine in the world. It was not as long as a book nor a one-off like a particular advertisement yet was longer than the newspapers in Glemria and had different advertisements. It was printed regularly like a newspaper but not every business day. Unlike a newspaper, it was printed on the same kind of paper as a book, thicker stock than a newspaper, but was thinner and with larger pages. The magazine had a paper cover of even heavier stock. The concept was explained in Djak's book and this magazine was based on an early London one. It appealed to the same people who supported the library. With the general technological changes and the drop in manufacturing prices, more had become richer. Although it had higher initial costs, with lower incremental costs and with more potential buyers, the magazine cost comfortably less than the price for which it sold.

For the first time, Djinbit wished he lived in a place with a store room. He already stored the wooden breadbox in the workshop. Perhaps he should convert it to a storeroom; now that he used Djil's exoatmospheric telescopes, he was not using the room as a workshop. That would make sense to other hexapedes. They would figure that no hexapede could beat the humans in astronomy and that as an astronomer, he did less. So converting his workshop into a storeroom would be good, especially good as the world became materially richer.

Ditertra liked the magazine; she was curious about everything and the magazine satisfied some of her curiosity. Djinbit liked it, too. The articles were not as difficult as the later ones on astronomy that he and she got from Djil: magazine articles were meant as relaxation. Ditertra found the same. Indeed, by comparing the two types, she saw they were not as complex as accounting articles written by hexapedes for hexapede accountants, either. The magazine came periodically — she understood why humans sometimes called magazines in general 'periodicals' — and was pushing a government-owned postal system that charged the senders, not the receivers. Moreover, that agency of government would charge a price that was independent of distance or difficulty in carriage. The magazine said it would have to charge more since it would be a sender but that overall, its customers would pay less, even when the customers paid postage all at once when they subscribed rather than each time they received the magazine. Ditertra saw that charging the

sender a single price would be a way for subsidizing mail to people who lived remotely, but that was probably good.

Djinbit saw that, overall, such a mail plan would be cheaper. That is to say, he was careful to think, 'so long as there is not too much corruption or inefficiency, it will be cheaper than having a bunch of private companies receive payment for delivering my mail.' Djinbit was beginning to understand that 'cheaper' meant 'wasting fewer resources.' Consequently, he was starting to act on cheapness. Of course, anyone could waste more resources and would if the prices he paid were not complete. When businesses received hidden subsidies, like polluting the air, prices were incomplete. Djinbit was not greedy. Like Ditertra, he felt that fairness was more important. He should pay a complete price. A greedy person would seek and hide subsidies or not even recognize them.

Djinbit wondered whether cheap fossil fuels were a form of subsidy; they had been to humans who had not recognized the subsidy for the longest time. The magazine had written about a law suggested by Djak that taxed non-existent fossil fuel companies out of business. Djak knew human history and tried to prevent the hexapedes from replicating the gruesome parts of it. Badly priced fossil fuels were cheap. The subsidy would not matter now, but would later. Fossil fuels were especially cheap where hunks were exposed or were washed ashore as solids or where they flowed as a liquid from springs. A few people could collect the coal or petroleum cheaply for themselves but companies that depended on fossil fuels could be taxed; so could individuals, but why bother? Individual people could more easily avoid paying taxes than businesses that had to sell to a huge number of retail customers. With high taxes on fossil fuels, only sustainable fuel companies could exist.

Chapter 46

Most hexapedes were not greedy; they thought greed was a vice. After earning enough to live on, they sought happiness instead. Djak despaired. He feared that hexapedes as a whole did not want enough stuff to become technologically advanced! He imagined poll or head taxes as human colonialists had used to force their aborigines to work. Then he found that such taxes were impossible. In Glemria, head taxes were unpopular and would be voted down. In the empires, powers either did not care to impose a head tax or felt that a high enough proportion of possible payers would avoid such a tax. It was much more obvious than an indirect one.

Fortunately for Djak, some hexapedes did want more than the minimum. They were greedy. For his calculations, Djak reduced the effective size of the population and found it would still be big enough to get the hexapedes into space and to create duplicators. It would take even longer and would leave more people superstitious than his previous calculations, but if the hexapedes survived as a technological civilization, opportunities opened.

Djak worried about a duplicator or a von Neumann machine, as he called it, even if it was in the distant future. As soon as one was innovated and publicized, he expected it to be taken over by a gang of the more powerful. An atomic one could duplicate itself, so he was really talking about a large number of them. One would become many. Even one that did not duplicate all of itself — 'without closure' was the jargon — could reproduce itself at a cheap cost so long as it did most of the work. Unfortunately, with an atomic duplicator, besides good products, it would be possible to multiply harmful bacteria to kill. It would only take one ruthless person to kill an enormous number. The other powerful would become paranoid, justifiably so. Ordinary people would become paranoid.

Harmful bacteria that could freeze were endemic and usually did not wipe out plants or animals. Plants, animals, and bacteria had evolved mechanisms so each species could live with danger. But if enough bacteria (or something else) that were harmful to hexapedes were duplicated, then technological civilization might not survive. Cold prevented too much thermal jiggling (and made it impossible to duplicate a hexapede without yet more technology). However, bacteria could be frozen and revived. And in the huge population that would exist, there would always be a crazy person who could get hold of a duplicator.

Chapter 47

According to the history of Earth, which Bellaria was reading, most recessions were milder than her first. They happened once every ten years or so, but with more than the usual amount of variation in timing. They did not happen randomly but not periodically, either. She decided that 'quasi-periodic' was a good term. Her first had been very hurtful; that was unusual. If human experience was similar to her planet's, every seven, eight, or nine recessions would be extremely hurtful and called a 'depression.'

It was clear that recessions that happened every ten years or so, roughly, were not caused — not fundamentally caused — by simple mistakes of one kind or another, although much was made of those mistakes and they hurt people. To be 'quasi-periodic,' recessions had to be the result of something in the system itself.

Bellaria wondered why the first was so bad. New industry had not been big enough to cause it nor had there been an agricultural disaster for several years before it. Maybe there was not a systemic cause for the first. Perhaps the 'common' explanation was right, that too much savings went into land. That investment grew and, then, when there was no more money to pour into it, collapsed like any scheme that suggested getting rich without someone's work. But why would investment grow? Usually, when investment grew big, returns dropped and more people than Bellaria dropped out. During normal times, the system was self-stabilizing, but not at the beginning of a recession or depression. A self-stabilizing system hurt the losers but a recession or depression hurt everyone.

As for systemic causes: 'Perhaps,' Bellaria thought, 'the time is long enough so most forget the previous recession from day to day, greed becomes more and more important, and suddenly every one wants to have the benefits, without working, of becoming rich.' She paused for a moment, '. . . where my phrase 'every one' means 'most investors.' They will hold their purchases or loans longer. However, when enough investors get scared,' she paused again, 'they can either stop enough lending or pull money back. Individual investors have no effect. A critical number is necessary. Then the system collapses at least partially and a recession starts.'

'Or perhaps it is fraud.' Bellaria thought. 'After all, Glemria has large accounting firms to look at the businesses that buy many properties. They are supposed to be respectable. However, when greedy managers of the private companies look for audit partners that stress aggressiveness and sophistication, the auditors have to be open to fraud. They can be deceived or commit fraud themselves. There is no need for conspiracy. Managers' — she paused; she was coming more and more to use the word 'manager,' even to refer to the chief — 'managers . . . can choose the auditors without much penalty. Besides, experts must

value property, which means a ruler' — she shifted back — 'must hire an appraiser who would also be 'aggressive and sophisticated.' '

Fraud would continue so long as markets were neither efficient nor fair; Bellaria knew that neither was the case in the present. Efficiency and fairness could not exist as long as there was no government policing, or 'regulation' as it was starting to be called, and no technical restraints. In other words, fraud would go on so long as it could not be detected and in the current scheme, which had little regulation, there was no easy detection.

Bellaria wondered. She knew that in Earth history, running private companies or public governments had been a much more effective way for rulers to commit fraud than as individuals without a company or government. It was mostly the most senior people; others, like the people in reputable auditing firms, went for high profits; yet others actually produced. Assuming anyone cared, they couldn't tell if the chief person was lying or not. Besides, ordinary people's own existence and income depended on being hired. Going for income and profit meant there were no signals of defeat. Indeed, in the short run, every measure was better, income and profit in particular. Only if you had a long term outlook did you see defeat.

The hexapedes did have a longer term outlook than humans, but did they have a sufficiently long term outlook in the right areas? Bellaria doubted.

Unfortunately, social and systemic losses were much bigger than the gains to one or more individuals. Bellaria knew that a portion of private companies had bought land when its price was low and then private individuals, like her, started to buy it as prices went up. She got scared and pulled out. Those who ran private companies sold their stock at roughly the same time and got raises because the companies had been so profitable. Then the price of land collapsed and all private companies ceased making profit. Nonetheless, rulers kept their raises.

Bellaria knew enough other businessmen to know that a portion of them were frauds who could and would deceive others since they were greedy rather than prideful. Wanting too much was not a virtue: it gave rise to criminals even though wanting was a virtue itself. With additional 'help' from the unsuspecting, the social and systemic hurts would be bigger than any profit. Moreover, there were enough such frauds to start the disaster.

That was another reason for thinking a portion of the old ways was better, that is, a preference for pride rather than greed. 'Of course,' she thought to herself, 'being humble and austere is even better, but the incentives are against that.' In Glemria, the incentives if you were poor would be not to starve and to gain a minimum; if you had more income, most would still want a bit more in order to appear ahead. It did not matter where money came from; more money meant more resources and more respect. In other countries, there was more honor, that is to

say, more pride, at least, among rulers. They paid attention to how others of their type made money. Unless most employees worked in old fashioned agriculture, the first generation of their rulers was shunned.

Bellaria suddenly realized that as far as she was concerned it was not money itself that counted, but the way it was acquired. In that sense, she paid attention to honor. The new businesses, the new technologies, had to be acceptable and in less than a generation. She felt that the old rulers could not morally survive. Unfortunately, they had resources; they could survive physically if not morally. Perhaps that is how many of the old empires had lasted so long, especially when technology changed very slowly.

It was changing much faster now. Moreover, the new businesses would have the same incentives as the old. Many new business leaders would be frauds, not all of them, but enough. That kind of fraud would be hard to prove, too. After all, a fraudulent company, like a successful one, would show more profits. It would have a reputable accounting firm. Only a huge amount of sophisticated government law enforcement could prevent disaster. That would mean paying more. Taxes would have to go up. So long as Djak's new businesses grew, that would not be too difficult; but when they stopped, impossibilities would rise. Still, it would not cost as much as mandatory schooling or, for that matter, income transfers, whether as the result of illness, pensions, army, or navy.

Bellaria asked herself whether leaders' fraud did more than start the first recession, which was based on a land bubble. Could the fraud start other recessions? It would take about a dozen years for enough frauds to forget the previous disaster. They would not know they started it! They would remember the results. Leadership fraud might be the systemic cause — some rulers of companies or governments would seek short term resources for themselves rather than honor or long term benefits. That would lead to people like her buying, a usually harmless activity for the economy as a whole. After a time, there would not enough people left so not enough purchases. Prices would drop and loans would be called, which would harmful to borrowers.

Whether that kind of disaster happened would depend on whether greed was more important than pride. Pride was mostly the province of the old fashioned and many of their beliefs should be condemned. They led to bad agricultural practices, people working inefficiently on large landed estates, and more thorough beliefs in zero or negative sum situations. They were bad. On the other side, the good side, lesser people were often truthful. Besides zero and negative sum situations, positive sum situations did occur. They did not only occur in love.

In addition to wanting her business to succeed, Bellaria wanted Djak's new machines to become commonplace. They were the only way she knew to eradicate poverty and still be civilized. She realized that civilization depended on at least an agricultural level of technology and

a civilization that helped everyone depended on a lot more. Without an agricultural level of technology you could not have cities because of a lack of food and sewers. With an agricultural level of technology you still had more than two-thirds of the population engaged in agriculture but at least a portion could do other things. They lived in cities. Most of the population lived elsewhere. Circumstances were not as just as in previous societies, but at least they provided more opportunities in cities.

Moreover, change would continue, albeit at a slower rate once Djak left. (Bellaria did not know of Djil at that time.) Changes would occur in less than a generation. Bellaria didn't see how the new economy could avoid larger concentrations than the present; nor did she see how it could avoid organizers. Since a small portion of people were selfish as well as short-sighted and an even smaller portion of them would rule companies or governments, honest regulators would have to police them. As a consequence, honest companies would be hurt and be less efficient because they had to answer the police. Government taxes would be higher paying for the regulators, who were the police. Her thoughts were depressing.

Chapter 48

Djak thought about his knowledge of human cooperatives: they came once and went once. Of course, all organizations that worked together were cooperative or, at least, the people in them were cooperative. However, certain organizations on Earth were called 'cooperatives' rather than 'companies' or 'corporations.' They were all organizations and although 'cooperatives' made or could make as much profit as any other kind of organization, it was a question of where the money went. Human cooperatives did not have the same kind of shareholders as companies.

However, too little pay for leaders was an error for private cooperatives. (Generally speaking, the government provided enough pay or other emoluments to senior people but not enough for ordinary people, such as clerks; not enough pay for clerks was another problem.) Another mistake was to have people try to do 'good.' That was a major reason cooperatives attracted employees. (In Glemria, government did the same.) After they received the minimum acceptable in their culture, workers put honor ahead of greed. They forgot about items that customers liked. In addition, they did not carry the authority of other professionals. Consequently, they did not sell to those who wanted 'goods' — those that tasted or felt good for a short time and did not hurt them for the longest time.

For example, human cooperatives that once sold food did not sell as much once starving people dropped below a critical portion, a 'tipping point.' The energy provided by sugar originally was helpful to poor humans who starved. The desire was helpful in the beginning; it was not helpful at the time of the diminution of human cooperatives.

Humans need leaders. 'Probably,' Djak thought, 'hexapedes do, too. In Glemria, leaders will became greedy. The inborn qualities related to leadership vary among humans in a Gaussian curve, like other inborn qualities. That is for ordinary humans; only a small portion of them are leaders. They are near an end of the Gaussian curve. Presumably, it is the same among the hexapedes of Glemria, where greed is a major motivator, not pride. Successful 'profit-making' organizations focus on one sociological characteristic, in this case, greed, and ignore honor. When only a few are greedy compared to the supply of individuals, they are paid more although the overall costs of the organization are less because they sell to a large market.'

Nervit, who was the son of Djinbit and Ditertra, started a cooperative when he was young: he was good at persuasion and administration. That cooperative manufactured sewing machines based on Djak's design. It acquired money from a large number of future users; Nervit spent enormous time setting it up. Even with the cost of training customers and the cost of repairs by his people, the business grew rapidly. The cooperative did not use much steel and paid all employees, including Nervit, a 'fair' amount. That was not much compared to Glatist and Bellaria. Nervit stayed with the cooperative while it was still excit-

ing, then moved on. By that time he wanted more than the cooperative could and should pay — even if he was the person making decisions — so he borrowed a huge amount of money from Teldor. He figured he would have to give more shares to Teldor than he gave himself, but that and pay, which would not be high, would more than compensate for the loss of his cooperative pay. His people manufactured tools, like most of Glatist's and the original men of Teldor. He chose the people and administered them. He was successful.

Chapter 49

Glatist was surprised when several husky looking hexapedes came to him and said, "We would like to protect you against fires.' He had never had a fire and figured they might start one. The spokesman asked to be paid. Glatist was in his office and as soon as they left, he was alone. So he spoke out loud and asked if Djak were with him. Djak promptly answered and asked, "Are you concerned about the crooks?" Glatist was amazed at how quickly Djak came and said simply, "Yes."

Djak responded, saying, "A non-sapient computer was monitoring your business and caught them early. It drew my attention to them and I heard the rest. Do the crooks look like this?" A mirror ahead of Glatist suddenly became a picture of the four hexapede 'heavies' and their leader. Glatist had not expected his mirror to change but moved up and down and said, "Yes," again.

Djak said, "I've converted several items to cameras and screens so we can communicate with more than audio. I have not told you; otherwise, you might look at my changes suspiciously. Now you know. Fortunately, if anyone besides Bellaria sees you looking at your mirrors, they will just assume you are checking yourself. You can look at them; just don't look suspiciously.

"I'll tell the police. They are not many, but they are enough. You don't have to worry about your business burning or anyone being hurt. Hmm . . . are you willing to be bait?" Glatist moved up and down. "The gang will go to prison longer if they are caught having spread an 'accelerant' but not yet lit it. You will have to say 'No' the next time the gang or its representative comes around. That will cause the leader and his helpers to try to start a fire. I have already had the gang followed by a bug. I'll tell the police to be hidden here and when to catch them. They'll probably have the fire department nearby, but it won't be necessary."

Glatist wondered what it would be like if he were not monitored. He was not sure he liked having his normal activities monitored. Without monitoring, he could do more, but would probably have to pay the crooks, too. Or he could tell the police himself. He would not have the same impact that Djak would, but the police were honest and would protect him. Most likely, the leader would send a representative to hear 'yes' or 'no.' That would save the leader from being caught if the answer were 'no.' On the other side, if the answer were 'yes,' then the money could be delivered in cash in a bag behind a tree, so the gang could claim they found the riches.

A representative came. Glatist smiled to himself. He had been right. He said 'no' to the representative, who looked surprised. That led Glatist to saying more, "We haven't had a fire around here; and now we have a fire department." He pretended to have not the foggiest idea what the gang was about. Three nights later, Glatist heard from

a police messenger that 'warned by Djak,' the police had watched the gang spread a liquid that could burn, said incriminating evidence in the hearing of the police, had not lit the liquid, and that he, Glatist, did not need to do anything. "From what members of the gang said in our hearing, you were being attacked. Also, Djak was right about the leader; we heard enough. We wouldn't need to question him, but we will for completeness."

Chapter 50

On his way to gather more financial support after the recession, Glatist met Rildung, a rich land owner who liked what Glatist was trying. Besides being a known liberal and investor, Rildung accompanied Glatist when he went to see certain people. They liked each other, which surprised Rildung but not Glatist. One of the people the two saw was Grildor, who ran a real estate company.

Grildor welcomed them and was polite. He did not smell bad yet neither Glatist nor Rildung liked him. Before leaving, they asked him to invest a little in the new business.

After they left, Glatist asked Rildung, "Why don't I like him?"

"I don't know. I don't like him either, although he comes from an old enough family and has been successful enough. We are in a big enough city — I am saying 'enough' many times — that I never met him before and don't know him. You do not need to accept money from him. If others do not make up for him, I'll invest more, so long as I don't own more than a twelfth of your business."

"Perhaps," said Glatist, "our dislike is because Grildor conveys excessive greed, not simply the amount that we exhibit, which I think is fine, but more."

"Yes, I gathered the same. He owns a great deal of land, or rather his business does. To keep him happy, you should probably give him a share of one-forty-fourth. That is different from what I said before and I think the investment is a good risk. He will make money off you. Still, I hope to have more and will invest more up to a twelfth."

"You will have what you seek," said Glatist, "and thank you for your confidence. Why don't you want to own more than a twelfth?"

"You are welcome. I don't want to influence you or be one of your councilors; I have found I can get away owing a twelfth or less." Neither Rildung nor Glatist thought that visiting people in each other's company and then talking was the same as being a councilor.

"I wonder if Grildor started or helped start the recession. He would have had agents whom he could tell to sell and very likely decided when prices were highest."

"The damage was much more than one person could have caused!" exclaimed Glatist.

"I agree the damage was huge," said Rildung, "yet one man could cause it, if he sold enough and others followed. Grildor could do that. It would make profit for him; it would be the others who would lose. Indeed, he may not see himself as the cause of the disaster. He and his accountants would think he made a good judgment deciding when to sell.

"Too much greed is a vice; we can only have so much desire."

"Yes," said Glatist. "From the point of view of the whole economy, Grildor produced a fictitious profit. Presuming you are right, and I think you are, he and his councilors and his auditors should have had a longer view. In any case, the majority of people enjoy a minimum for living and less than the amount required for happiness; if you have more income than you need for happiness, there is little or no increase with a growth in income. Yet some, a few, want more and become leaders and become frauds. We must have honest laws and honest regulators. That is the only way to give other leaders and creditors a chance, whether they be employees, shareholders, or bond holders. It is the only way to give the general public a chance.

"The leaders of private businesses will," said Glatist, "eventually, control those who control the government. The frauds among them will persuade voters that 'government is the problem.' Voters are made up of your 'general public.' There will not be sensible laws and regulations; after all, it takes honest laws and honest regulators to put deceitful people in jail."

"As for what you've said, it's true," said Rildung. "If you think 'government is the problem,' you have already been fooled. No one wants to admit they have been made a fool. Besides, the frauds' explanations seem to make sense."

"At least, we are not like Earth," said Glatist, "where more than a few people gained income from the new fraudulent practices, yet not the majority, and we are not an empire in which people think well of deceit beyond the family or clan since that means keeping money from a government that steals.

"We have enough old practices, like controlling a business that owns land, that frauds can make a profit even when they hurt everyone else. New practices simply increase opportunities."

"Yes," said Rildung; "as far as I can see, all we can do is support the regulations that Djak proposes. The humans have had bad experiences. We need not duplicate them; we can invent our own."

Chapter 51

The almost civil war to the south had implications. Hardliners among the hexapede legislatures wanted to invade the neighboring colony and although they were a minority, they were a larger number than Djak expected.

Those who wanted to invade had a lose-lose mentality, except they did not see the war as losing. They would not suffer the risks of being in 'their' army and they were not in Ildong's colony so they would not be victims. Ildong would counter-attack, but Fortenst would prevent Ildong from sending a large number of troops. They saw that powers in Glemria would benefit. For them it would be a win.

It was a classic agricultural point of view, that winners would be better off, both in terms of deference and in terms of materials, both pride and greed. Moreover, it would be true, in a limited way, with an industrial technology and more so with an agricultural technology.

Djak remembered telling Djil that powers might not extend their notion of 'us' to cover everyone, not even when they could escape, whether that meant they could leave their locality, their planet, or their system. He was seeing the effects early, when powers could simply move from one place to another on the planet. He was afraid they would not think of victims as 'us.'

Unfortunately, those Glemrian powers were right: successful invasion would provide Glemria with more resources and more workers. Indeed, if the victims did not fight back, that would be true so long as there were no atomic duplicators. With duplicators, everyone could have material abundance.

When some of the victims fought back, the Glemrian fighters would become more effective as the army went forward. Defenses would also become better as technology advanced yet offense would still be more effective. Even if the victim fighters in the colony did not mind dying for sure and invented suicide soldiers, offense would be cheaper. Moreover, a Glemrian invasion might appear successful and, if the history of Earth were any guide, might be successful for several lifetimes. It would all be a waste. Defense, offense, security, and war: all cost.

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After a few years, Sligtor tried to persuade Djak to make him a house next to the observatory where he already lived. Sligtor wanted more. He had become greedy for material objects, not for power. He liked being an astronomer at the leading edge, as he was. Djak refused making another house. Sligtor said, "I'll describe our history." Djak still refused although he permitted Sligtor to continue to use extra-atmospheric telescopes and be an astronomer. Djak did not want to be

blackmailed. Instead, he conceived of an idea: he would announce that he had made some in-space telescopes for a few astronomers and that he had sent their reports to Earth using the fastest means of communications possible, which was radio. The reports' travel time was nearly three dozen years one way; it took nearly six dozen years to receive an answer. Djak said that he wouldn't do this for everyone but that a few astronomers had a sufficiently long time horizon to wait.

Djak did this both because he did not want any more attempts at blackmail and because it would be difficult to keep secrets a long time.

He said that Djinbit, Ditertra, and Sligtor had been his choices; they were young enough that they might hear a return message. The few other astronomers were either too old, incompetent, or had changed their careers.

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Sligtor did not receive more yet accepted the situation. He liked being an astronomer. His blackmail — he thought of it as 'negotiation' — he perceived as a gambit that failed, like several of his dealings with the university. He figured that some dealings with his university succeeded and some failed. He appreciated Djak's solution: it was long term and did not hurt him. He could make his spectacles public. They controlled his telescopes as well as showed him their views. After Djak made his solution public, the only downside as far as he was concerned was that some of his colleagues at the university started calling him the 'young Sligtor.' He did not think of himself as young; moreover, he planned to retire before a message came back from Earth.

Chapter 52

Djak asked Gladist and Bellaria to build a few quartz clocks. The crystals had to be big but they still existed in Glemria; they were not cut up to make small crystals, as had happened on Earth before atomic duplicators. The motion of the quartz pushed a rod which touched and broke an electrical connection many times a second; it was mechanical to electric rather than mechanical to electronic as on Earth. The hexapedes could not produce a good enough vacuum to create electronic amplification, although Djak expected that soon, using mercury drops to produce the vacuum, as in the 19th century on Earth, and getters. Solid-state electronic amplification was still a long time in the future. The very small mechanical tolerances required a low voltage as well as experts when they built quartz clocks but not after.

The broken electric current moved a tiny bar which rotated a wheel that carried more current and voltage. The second wheel was geared down and moved another bar. The third electrical system carried enough current and voltage so its motor could move the hands of a clock face and a hammer that struck the quartz at intervals that were timed for least damage to the quartz. The hands marked Earthly seconds and came back to zero every midnight. A mechanical albeit digital display showed the number of seconds from the beginning of the year zero. The clocks were built and kept in a chilly part of the basement that hardly changed temperature. Although the clocks were subject to changes in temperature, the changes in the basement were not as much as any outside.

Djak told Gladist and Bellaria that he would provide a 'clock checking organization' that would be separate from them. It would be open to all; however, at first, they would be the only people using it. He would also provide 'clock checkers' that were extremely accurate. "By the time I leave, which will be a few lifetimes," he said, "you'll be able to check clocks. Meanwhile, I'll be inconsistent and help directly."

Djak's 'clock checkers' made their decisions quickly since the quartz vibrations were slow to them. Consequently, he only had to provide one 'clock checker'. It could do two checks on each quartz clock, one at first and one after a time. That made it possible to check the rates at two temperatures, not just one. (The temperature variations were not large, but readily measured by Djak's 'clock checkers.')

Less accurate clocks — they were made the same way but suffered more of a temperature error since they were not in a hole in the ground — could sit on those ships whose owners could afford them.

Determining longitude turned out to be very important for shipping. As Gladist and Bellaria's workers learned how to make quartz clocks more cheaply and Bellaria dropped prices, pushed by their captains, ships' owners bought more of them. The captains had always been able to find latitude but finding longitude at sea was another matter. To

come to a destination, Earthly ships had inefficiently crept along a 'line of latitude' and hexapede ships did the same. With accurate clocks, packet ships connected major ports. They kept currents behind them and went to their destinations. They could not tell when they would get at their destination because of the wind. However, they could define when they left and go to their destinations by the fastest general route. (Djak did not tell them of local winds or warn them of big storms.) Other ships with accurate clocks acted similarly. They were not packets yet they went to their destinations by the fastest general route. This both saved money and made shipping safer. Owners who did not go to sea liked the first; captains and everyone else who went to sea liked the second.

Also, cities and companies displayed the user interface of clocks; they displayed huge 'faces' with hour, minute, and second 'hands.' Since the second, which was from Earth, did not fit, the faces went to zero at midnight. Djak expected the widespread public availability of time would change the culture slowly over several generations to one in which in which most people paid attention to hours and minutes rather than make their estimations on dawn, morning, noon, afternoon, and dusk or evening and night. Industry would catch up; machinery would go faster.

Chapter 53

Fortunately, or perhaps, unfortunately, the beginning of Djak's industrial revolution succeeded in Glemria. More people in that country were greedy than prideful. Ordinary hexapedes everywhere wanted more stuff. In Glemria, they got it. New people, mostly middle class, became organizers of the huge number of different goods that development produced and required. Mostly their first end products were the same as those in a later agricultural society but made more cheaply using Djak's machines and no internal tariffs. The organizers had others copy at the proper level of technology one of the designs (Djak made it easy to determine what could be built and what could not), had others make sure the notion was complete, acquire resources, keep morale high, and push production. It was difficult, but there were enough entrepreneurs and followers.

Doors were standardized, so machines could cut and carve them. Djak designed those machines. Houses came to be built of standard parts: doors, beams, then walls, ceilings, and roofs were built ahead of time. Even earlier, chairs and tables had been built using Djak's machines; so had rugs. None of the machines were intelligent, but they were better designed than the original machines in the early days of the industrial revolution on Earth. That was an advantage of coming later.

Houses were not as cheap as they became on Earth with the development and eventual use of three-dimensional printing, but were cheaper than before, just as had happened on Earth before duplicators. The beginning of the hexapede industrial revolution was successful. Moreover, Glemria started to establish a national registry of property. Other countries would follow. It meant the rise of real estate businesses in which strangers bought property in addition to insiders and locals. Moreover, the government passed laws which established banking offices that not only could loan the money but also find people. Banks had to be able to pay off their debts, so finding the right people was important. The banks — they had a huge number of offices, but there were not that many banks — were not run by that many frauds and kept debts to themselves; they mainly loaned to people who planned to live in their 'own' houses and were therefore more likely to pay off their debts. The banks also loaned money to build industry. That was more open to fraud — especially from leaders who made extreme profits and were 'vetted' by reputable accounting firms, all of which was legal — but the laws also specified 'onerous' regulations, as some termed them: they used more resources, which was bad, and prevented much fraud, which was good. Other governments were slower.

The disadvantage was that people in other countries acquired less. The powerful in those countries put honor and the 'good old ways' ahead of greed.

Tax revenues in Glemria increased as did its technology. Eventually, it became a leading power. However, the politicians were more inter-

ested in people than technology and did not recognize immediately how much power the country had gained. National powers, the people who were successful and commanded the army and navy, could have had a small force conquer people in other countries cheaply. With Glemria's technological superiority, the country did not need a huge army and navy. It still needed big ones since it was not fully advanced, but it could conquer all the others. They had a lower technology and were weaker.

Chapter 54

Bellaria and Glatist ended up having two children, a boy, Gondril, and a girl, Clarigtar. Bellaria refused to have more although they could afford them, saying falsely, that she was too old. While the children were still infants and young, Glatist disregarded them except to notice that Gondril paid too much attention to his peers. He finally became the kind of person that Glatist thought might be a good heir. Clarigtar learned all about her environment, including other people. More than her mother, she was interested in marketing, whether for an oligopolistic or a competitive company.

Ditertra and Djinbit also had two children. They could not afford more; they worried about expenses. But they replaced themselves. Neither child wanted to become an astronomer; indeed, neither child seemed dedicated the way their parents were. Both Ditertra and Djinbit thought that might be because of the way they raised them. Djil gave Ditertra and Djinbit the records of another species and they read the human child psychology books with interest.

Djil provided them with the most recent research she had. "Hardly any research on humans within a generation or two of the beginnings of electronics is any good," she said, "and little or nothing before that." Fortunately, Ditertra and Djinbit thought that both their native stories and the stories that were aimed at human children were fine, even those human stories written in the generations around the beginnings of electronics. They did not think in terms of cultural changes. Many of the human stories could be readily rewritten for their own planet, even if it did have numerous differences, including three times the surface gravity. Other stories could be read in the original translation as an introduction to a very different species — for one, humans stood up; for another, they had only two arms. At first, the children thought humans were imaginary.

Djak provided the same knowledge and books to Glatist and Bellaria. Then he gave them to everyone else. His first edition of 'all human scientific knowledge up to electronics' had not included more recent research on humans. Djil tested ideas on Djinbit's and Ditertra's family but did not want to be bothered like Djak.

Djinbit remembered that when he was young, he had overheard children even younger than he and, young himself, realized suddenly that he could predict everything they said once he knew their topics — for some reason, he had not realized that before. 'Perhaps,' he thought when adult, 'before that time, I was too young for the realization.' As an adult, he wondered to what extent he was predicable? Then he decided that he was predictable in general but not in particular. He stopped wondering. Djinbit had not told anyone and wondered what the two children experienced that he did not know.

Helria, Ditertra's daughter, married Gondril, Bellaria's son. Although they were born at about the same time and lived in what was

effectively a small town, none of the children growing up knew each other except at a distance. It was not until their adolescence that Djil, as 'Aunt Djil', introduced Helria to the two others when Djak brought them to the observatory. Djak introduced the pair's son, Nervit, to Clarigtar, Bellaria's daughter, at the same time. However, Nervit and Clarigtar did not fall in love as Helria and Gondril did. He did not marry for the longest time and not to her. Djinbit explained the exo-atmospheric telescopes to both Gondril and Clarigtar. Both listened attentively but neither became astronomers.

They put on the extra spectacles, which Ditertra and Djinbit had kept, and were amazed at the pictures. Neither looked at spectra. Helria and Nervit, Ditertra's and Djinbit's children, knew about both pictures and spectra but did not care.

As an adolescent, Nervit paid more attention to Glatist. As a young man, he first started a cooperative that made sewing machines. Then he wanted more money than he was paying himself and went into the tool making business as another oligopolist after gaining money from Teldor. His business was not as successful as Glatist's and Bellaria's, but was successful enough. He employed Clarigtar as a marketer.

Chapter 55

Djinbit spoke to Djil, "You think in terms of four temperaments. I am not sure you should publicize that as it complicates matters. I read Fiske's *The Structures of Social Life* as well as Plato, Aristotle, Galen, Myers, Briggs, Keirsey, and the theory that mild forms of fairly common mental illnesses might shape character.

"They are bi-polar, obsession, schizophrenia, autism, and Tourette's syndrome — that's five. Plato, Aristotle, Galen, Myers, Briggs, Keirsey, et al." Djinbit said, "fit Fiske, if his work is taken as showing temperaments; they are four major temperaments. At the same time, I do think it's true that the theory that mild forms of fairly common mental illnesses does shape character but I would prefer five or more rather than four. On the other side, having a mandala of four is useful. It is certainly useful for the people versus non-people distinction as well as abstraction versus non-abstraction.

"Still, I think that Lakoff's idea of familiarity is more useful for most purposes than whether you can point or not; that is what the non-abstract versus abstract distinction is about. Of course, just about everything you say is familiar; that is the point, to use the word 'point' in a different way. But leaving that aside, in the mandala, the concrete versus abstract distinction makes sense: you can point to the concrete, such as kissing, but not to the abstract, such as love. So that distinction is useful. With that and the people versus non-people distinction, you have a complete mandala, all four items. I don't know where to fit the reporter versus director distinction; it looks as if all four temperaments have it. The four also have the familiarity/non-familiarity distinction. The four are very general.

"But not general enough. When you have powers thinking every one is more or less alike, they will push economic development more because they will figure they can sell more. Only when you have planetary impacts do you want powers to aim for a stable economy. Then you want powers to prefer honor as a virtue and greed as a vice rather than as a virtue. That applies both to powers in government and to powers in private industry."

Djil said, "Are you suggesting censorship?"

"Yes," said Djinbit, "at least, among famous people, such as Djak. Every word he says is investigated. It is not so strong for what he has written or released as examples and perhaps that is the difference. You think that what is written and what is spoken as the same; so do I, but not everyone. I don't like censorship any more than you do. It gives too much power to the censor and none to you or the rest of the ecology; but, I see that every culture focuses more attention on one hand rather than the other hands. That is a kind of censorship.

"You want more people to prefer greed rather than pride, so they will want more material objects, so they will develop economically. That is

fine; I agree. It is better that people eat more than starve to death. But a side effect of that is you want to increase the portion of people who are greedy. That will increase the supply of people partly because you will make it easier for them and partly because greedy people want more children and your and Djak's medicines are likely to ensure that more of them survive. Greedy people make it more likely we will develop economically. I agree.

"Some of those people," said Djinbit, "will have the power and contacts to develop the world economically and will want to. They will read but the investors are less likely to. The investors don't have much money. They buy too few shares; but, as a group they provide a large amount of money. A majority of the investors will remember the spoken word and the entrepreneurs, the written word. So when I talk about censorship I mean of the speech of famous people, not what they or others write."

"You mostly take in knowledge by reading," said Djil.

"Yes," said Djinbit, "and you could argue that I would not be effected. That is true. But I think of those who cannot learn to read or who have learned but won't read and wonder.

"You are arguing for 'security by obscurity,' " said Djil.

"Yes, I suppose I am. My proposal is very easy to crack; in this case, all you have to do is read.

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"You have machines that can produce just about anything, including themselves," said Djinbit.

"Yes," said Djil; "we call them von Neumann machines. Von Neumann was a human mathematician who wrote about them in the 1950s. Ours can reproduce atoms. We have one that can reproduce itself and have a large library of designs — blueprints, they used to be called — that a von Neumann machine can manufacture of what does not exist at the moment. We also call them duplicators."

"Even when we cannot reproduce extremely small items . . . "

"We call that 'lacking closure;' well, no," said Djil; " 'lacking closure' is when you don't have all the inputs."

"Even when we cannot reproduce extremely small items," said Djinbit, "they are dangerous: if you can manufacture everything except extremely small items, all you have left are services, land, and food. Land will be controlled, directly or indirectly by the state, which is to say, by the most powerful thugs. That will be a kind of service. Food will have to be grown. It will be made when you can duplicate extremely small items. Even when you cannot do that, with von Neumann machines producing tools, not so many people will be necessary to grow

food. Some people will go into services; that will be all that remains for ordinary people.

"The rest will be killed by the thugs because they are not smart or because they are fooled. Certainly, they won't be smart enough to manufacture as powerful weapons as the thugs, although a von Neumann machine will be able to. We only need one not-very-good von Neumann machine since it can reproduce; one can become many. I know, it won't happen in my lifetime, but it will in the next or the one after it."

"Yes," said Djil, "and I cannot see any way to avoid it. I suspect we will have to stay to prevent overt and open warfare. Once you have electronics, somebody will organize the requisites for building a von Neumann machine. It will come sooner or later. Even without us, you will develop it eventually. Assuming we don't exist, and presuming you don't collapse first, which I doubt, the course of economic development will lead to a von Neumann machine. You can hope that the powerful forgo superstitions and are good people, but that is unlikely. The most you can hope for is that those who initially control the first machine will be good. That is what happened with humans, who were lucky.

"Only powerful thugs can prevent the development of von Neumann machines and only for a few generations. Then, even if they are part of a world culture or government, innovation will occur. A group will gain the funding to design and manufacture one von Neumann machine that can then reproduce. The scheme will be attractive to the funders, even if development has to be hidden. That is because thugs, who I am presuming have the money to provide the funding, will like the guns a von Neumann machine can produce.

"For example," said Djil, "some group that wants more power will organize. Sure, more powerful thugs will try to suppress groups below themselves even if they are attractive, but it takes only one group. That group will produce guns and overcome the formerly more powerful. That is because some group who is not at the new top will want to be at the top. The first group will try to prevent anything else from being produced. Yet once the knowledge of a single, general, and perhaps unclosed von Neumann machine is known, material wealth for everyone comes within a lifetime or two. That is, with or without our existence. Someone's von Neumann machine that is not as well restricted as the first and not necessarily one that manufactured guns will make a duplicate of itself. After that, of course, you will have warfare, but hopefully enough of you will survive to recreate a civilization that is good. That means enough people have to survive with enough knowledge and at least one von Neumann machine."

Djinbit nodded.

Chapter 56

Over time, human cooperatives' leaders noticed that they were smaller and other organizations more ruthless. As they became older, a fair number — not all — of their leaders moved to 'profit-making' organizations. There many tried to be good as they thought 'good' should be, but eventually adapted to a local culture in which 'good' had been defined by the owners as making a profit in any way. (Many of the owners were small and distant investors, not hands-on rulers. They invested because they wanted returns.)

Nervit was a good hexapede, yet he wanted more; he was like his parents in wanting more, but not like them in wanting just data related to astronomy.

In other countries of both planets, for local powers and for many others, pride came before greed. While that should have encouraged cooperatives, since that was one of their attractions, that was not the case. The argument against them was that the new-style cooperatives on Earth had not existed in the past and should not exist now. Consequently, those existing were destroyed and new organizations prevented. 'Profit-making' organizations had always existed. They were encouraged. The same happened among the hexapedes.

Djinbit, Ditertra, and Sligtor continued to use their exo-atmospheric, electromagnetic radiation observatories. (They did not look at gravity waves or anything like that.) Djinbit preferred arguing with Sligtor, who was a good astronomer. He made useful comments. However, Djinbit and Ditertra first discussed their findings with each other. Sligtor was distant, older, and controlled his own observatory. He had been one of Djinbit's teachers. Djinbit and Ditertra mainly communicated with Sligtor using the 'spectacles' that Djil had given them and that they used to communicate with and control their telescopes.

Before Djinbit and Ditertra pretended to die, they heard from Earth that astronomers there thought well of them and they were famous among the rest of the humans as being the first non-human scientists known to Earth from their planet. Sligtor pretended to die and was a dead particle before any such messages came from Earth even though messages on the way kept coming to him 'or his successor.' Other astronomers on their own planet knew that Djinbit was the humans' astronomical conduit and that he had married another astronomer. They knew that he and Ditertra were two of the three astronomers chosen to receive Earthly telescopes. They did not know anything about rebirth, which the three enjoyed; Djil had explained the secrecy: " Djak and I don't want to tell you hexapedes because your technology is so backward. It will require several lifetimes and the growth of schools that support engineers and scientists before you can do any of it." Nonetheless, the three waited a long time to receive the appropriate messages from Earth. It was too long for Sligtor until he arrived at the other planet and was revived. (Indirectly, the human computers provided in-

comes to the other hexapede astronomers. Their jobs had become an effort of proving what was already known. There were very few left. Several had stopped being astronomers and started new businesses.)

Both Djinbit and Ditertra were old by the time a transmission got back to them about their first report; fortunately, the report was very good and so was the message from Earth. They had sent the report almost six dozen years before. Since it was the first, they remembered the report vividly. Also, they knew the transmission would take a long time to go between stars.

They toasted each other, Djinbit smiled in the hexapede manner: "We are about as far away as far as anyone can be and still receive messages back within a non-extended lifetime. I think it is a good idea that the humans have, requiring that every six dozen human years they lose everything but their memories. They lose their material objects and their positions. I would not mind keeping my memories and living in a younger body, but I am not so unhappy about dying either; we have lived a good life."

"Yes, we have," said Ditertra.

Although it was faster than physical transport, radio carried less information. Nevertheless, Djinbit and Ditertra's report had enough information and was liked by the human astronomers. After all, they had reported on a topic that no one else sought and although it was not as important as those that both humans and hexapede astronomers put first, it was respected.

Then Djil came in and Djak spoke though her; this was unusual enough that both Ditertra and Djinbit listened. "We followed Earth's directions and built a dense collection of sensors around this star. That was because the Melians had a scare when an alien space ship bounced against a sun a planet of which they were settling.

"After a time, our sensors told us about a moving light beyond your solar system. We resolved it. It's a deuterium exahust decelerating towards a nearby star at less than a half a human gravity, less than a sixth yours. We projected its course backwards and it seems to have come from an early K type star. That star has a planet orbiting it with the same gravity as its deceleration. The planet has a moon oriting it, too. The rocket is going to another early K type star with a planet orbiting it with just a smidgen less surface gravity than the rocket. That planet has no moon and no signs of life at all.

"We think the technologically advanced, intelligent species comes from a planet with a weak gravity that is nonetheless good enough for them, although no humans would have settled there, nor would you have, either.

"So we will break our rules and give both of you rebirth, along with Glatist, Bellaria, and Sligtor; first, we want more people to investigate; second, your planet is close and you know of extended life. I know you

don't want to, but you'll make decisions for your planet. Moreover, you won't be surprised by rebirth.

"However, you will have to pretend to die forever and we will change you a bit when you come back in two generations or so. You will appear to die before Glatist and Bellaria but won't wake again until the next star."

They appeared to die quietly and within a short time of each other. Djinbit died first. Ditertra had Djil but she wasn't a hexapede and Ditertra did not respect or like any other hexapede. She liked and respected Djak, but he wasn't a hexapede either. Ditertra was lonely, but kept on working. She reported Djinbit's death to Earth and said she would die soon. She reminded Earth people of hexapedes' general level of technology.

Djil reported Ditertra's death.