CHILDREN

OF THE

THIRD BRAIN

Episodes from the History of Science on Planet Gabo in the Pentomino Universe.
Or
How Science Could Have Worked Out Slightly Different In Another World.

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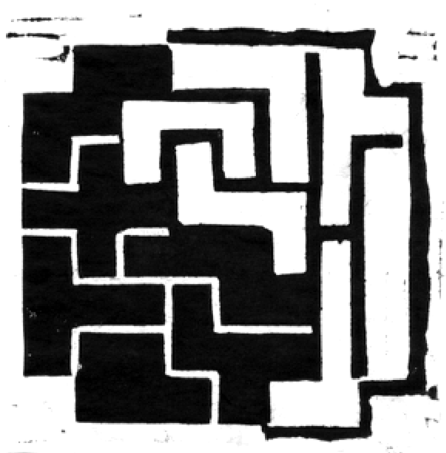

TO MY MOTHER

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NOTE

The book is an attempt to describe an **alternative history of science, not an attempt to predict and warn about the future of today's science**. I would consider the latter an act of idiocy. Nevertheless, it tries to stay close to some of the actual events and ideas that happened on Earth. The reader will easily recognize the various allusions to them and will, hopefully, enjoy the intellectual 'tickle' of seeing how slight deviations from these events and ideas could ultimately lead to quite different explanations of the world. For reasons of clarity I did not alter some names such as Fourier, Fibonacci, and others. I have to confess, I was struggling whether to leave in the book the pentomino-version of base-pairing and the double helix of DNA. This part is probably overdoing it and rather silly, but I thought it was fun, nevertheless. The end of the book was inspired by the ideas of Paul D. McLean (1913-2007) that our brain is a three-layered complex of three essentially independent brains, which represent three major stages of brain evolution, as may be simplified as the evolutionary sequence of "reptile→horse→man".

THE DISTANT PAST

Death of a Perca

The beast howled in terror. He had dragged his scale-covered body through the night that had suddenly fallen in the middle of the day, and exhausted, had caught his left hind foot between rocks. Fifty times heavier than a human, he had crushed it in one panicked move. He tried to get up by thrusting about his limbs and tail. The terror overrode the pain. When his tail caught a tree stump, and his body rolled over his broken leg, he hardly felt it. On three legs and his tail he limped on. Hundreds, thousands of smaller animals scurried by, heading east like himself.

When the quake struck, the giant perca had been feeding sleepily in the swamp. His tongue, covered with millions of cornified hooks had pulled the juicy Bembra stems out of the mud. He cherished the taste of the stems, spiced with the little snails that covered their roots. Ever so often he would raise his head and roar his territorial call, which was answered invariably by a flurry of birds in the overhanging branches.

Saliva and mulched Bembra dripped down his chin. It ran down the two soft tentacles that lined his mouth. Females had longer and deliciously soft tentacles. The perca had loved often in his life. Maybe, the moans in between chews were sighs of his memory of female tentacles, so gentle and so sweet in creatures armored with impenetrable scales all over. He was older now, still, every spring, he still watched out for the yellow birds that cleaned the scales of the percas. They betrayed where females were, and he would charge for the area and start a delightful chase to the edge of the swamp where the two steaming giants submerged into softness. Oh, it was spectacular in the spring to see the weeds wave where the percas raced, and to watch the flocks of yellow birds follow their masters underneath. Like yellow seeds driven about by gales they floated here and there until at the swamp's edge they fluttered above the two lovers and with disrespectful, excited chirping demanding immediate return to normal behavior.

Following the first rumble of the quake, the yellow birds were blown away by a terrible wind. It tore many of the giant Bulga trees into the muddy waters over which they had spread their branches for centuries. Then the wind settled and an eerie silence fell while a black wall began to rise in the west, a bluish-black boiling wall, cracked open by lightning. The frightened percas started to wade their heavy bodies through the mud. At the eastern edge of the swamp they came to dry land, and four times as heavy now that they were out of the water, their terror rose as the black wall came nearer and nearer. With eyes rolling in panic they bulldozed down trees and bushes, and stumbled into cracks and mud holes.

Presently, the wall began to roar and scream and thunder. The air grew hotter and dustier. At first the wind blew it up from the ground, but now the dust came from the wall itself. In fact, the wall WAS dust. Boiling hot, hundreds of times heavier than air and with the speed of a hurricane the front of the volcanic eruption reached the perca. It hurled him up like a feather, smashed him into the ground, and fell on him like a slab of rock. There was instant death. His limbs were twisted in a bizarre gesture, the huge scale over his neck snapped off, his tail broke, the giant tongue blocked the mouth in a last attempt to save the lungs from the dust. The perca lay on top of a deer and two ratas that the hellish storm had hurled underneath its body.

Within seconds it was deeply buried in dust. The sound of the thundering wall muffled by the layers above, receded in the distant east. Unheard silence fell. For a while the buried waters rumbled on. Then they fell silent, too.

Two more eruptions followed during the same night. They spread a greenish dust layer over the first blue-grey dust. Soon deluges of rain followed. Together with dust and molten rock, the volcano had spewn out vast amounts of steam that were now condensing and soaking the dust. Heavy with water it settled down and compressed the bodies underneath. When the deluge of mud from the flanks of the volcano finally arrived at the grave of the perca, it dumped more bodies on top and stirred up some of the upper layers of the compressed dust, but it left the perca's body undisturbed.

Like a child pressing a flower between the pages of a book, the planet had thus preserved the flattened image of a perca, before the magnificent creatures vanished a few million years later.

Many, many Springs followed. There were no more flocks of yellow birds following the delightful chases. There was no longer the softness of the tentacles. There was no more glitter of the colorful scales. The pages of the book hardened into rock. In the silence of eons, the slow voice of the crust was heard every so often, adding other flattened images of creatures to the planet's collection in the rocks. They, too, had to leave forever when their time had come, but others followed that were equally magnificent.

Seas came and went. They covered the rocks. Sand and silt layered on top. The volcano, after many peaceful eons, erupted again and again. At times it was covered by deep seas, and the eruption created an island. The magma hardened, and eventually eroded. Stray seeds carried by the wind fell upon the newly forming soil. Plants grew, new creatures chased other new creatures in the rich forests that covered the flanks of the silent volcano. And then it buried them again, hurling a few survivors across the sea to the shore of a new continent that had arrived nearby during the past fifty million years.

Presently, the crust buckled up. The rock layers moved back to the surface. The upper ones cracked. Water and wind ground them back into dust. It was still eons before the time of the first humans, when the perca returned to a layer a few feet underneath the new surface. Finally, humans appeared. They developed agriculture, metals, and art. Sorcery changed to legends. Legends were replaced by teachings of nature. As humans learned to build in stone, they broke quarries into the hills and dug up ancient stones, hoping to build for an eternity that would hardly outlast the volcano's next awaking.

When the layer of rock was lifted above the perca, and the light of the sun fell on him again after unimaginably long time, a new creature looked at him. The creature was soft all over. No scales, no shiny colors. With terrified eyes a little boy, young Wardon, stared at the first fossil animal of his life.

The demon in the rock

For the last days the sun had rapidly melted the snow patches even in shadowy corners. The old quarry sheltered from the wind already hummed with heat and insects. The raspberries blossomed between the rocks. High up on the hill whitethorn bushes and Caparas sent clouds of yellow pollen along each gust of wind.

The quarry was Wardon's secret hiding place. The old rusty machines overgrown with vines housed many colorful birds and lizards. Yet, there was always a strange silence underneath the chirping and humming, as if the gay sounds of life covered a deep well of mysteries.

Every day after school he went into the woods. He followed the trail through the blue cherry fields. At the edge of the pine forest he dodged under a belt of vines, where a leap brought him into the cathedral-like grove of ancient giant pines. There he walked on the slippery floor of their needles. Only his occasional cracking of a dry branch on the floor broke the silence, and although he felt the kindness of the ageless giants towering above, his heart pounded while he entered their empire. Sometimes one of the giants bowed upon a gale. Then, high up in the roof of the sacred cathedral, a window opened into the sky, and sounds from outside invaded the silence for an angry moment.

Midway through the forest ran a creek. No weeds lined its path, only pebbles covered with moss. Wardon sat and watched little rafts of pine needles arrive from somewhere upstream and pass by, or land at one of the drifts of needles that filled the space between the pebbles. He dreamed of adventures in a distant land where he was a strong and daring lumberjack guiding his raft through the perilous rapids.

It would never be. His left leg was shorter than the right one. He limped. He was grateful that the ancient giants did not seem to mind. They smiled, and bowed to the occasional gusts overhead.

At the edge of the pine forest the ground rose. A few more steps and the Easterday-field lay ahead of him in the glaring light. In the summer, its grass was taller than Wardon, and it moved and whispered. Many blue wheaters tumbling in the air and landing on poppy blossoms would make him dizzy with their mocking dance. Now, in early Spring the grass lay brown and dry on the ground, yet thousands of lion-ear flowers covered the field with their lush purple blossoms. A few more steps brought him to the edge of the quarry looking down its steep precipice.

He climbed down. His shorter left foot forced him to step mostly on his right, but he mastered it very well. Halfway down the rocks, he noticed that the profile of the south rim had changed. Apparently, a whole section of the upper edge had come loose and fallen to the bottom of the quarry. He climbed back up, taking great care not to step accidentally on one of the sacred-cross snakes that had returned from their hibernation caves to the southern part of the quarry.

There was a big scar on top of the hill. Grass, topsoil and a few layers of rock had been torn away, revealing a flat slab underneath. It stirred his little boy phantasy. What a wonderful little house he could build there for himself now! Surrounded by natural walls on three sides, with the flat rock for a floor, it needed but a roof of branches and vines. There, hidden from view, he could look out over the quarry across the valley to the distant Swan-mountain, the ancient volcano, that had been silent as long as humans could remember.

Stirring around the rubble that had fallen from the edge of the rock slide, he found for his collection a new stone with 'rock flowers', as people called the brownish, delicate impressions of leaves in the rock.

They were the witnesses of the story about the princess and the giant sorcerer. As she did not return his love, the sorcerer had summoned his magic powers to turn her into stone. Yet, in a nick of time a fairy had averted the curse. With gigantic thunder the sorcerer's evil magic tore only the flowers from the princess's golden hair, and scattered them into the darkness of the rock, where one could still see them.

The many rock flowers he found in his hiding place had convinced Wardon that the story had happened near the quarry. It was all the more likely, because the old people of Perca told that the sorcerer's castle had stood on Swan-mountain.

The story went on to tell that the powers of the fairy had turned the curse of the giant sorcerer on himself. As the wreath crashed through the rock, so did the sorcerer. He had to be around here somewhere. Wardon was sure.

Lulled by the secret sounds of the quarry, Wardon liked to dream of his princess. He imagined her sitting above the quarry with the wind playing in her golden hair. She would smile at him. Oh, this kind and lovely face!... The new rock floor was an ideal foundation for the palace he wished to build for her. Together they would live in the new castle, looking out over the valley to Swan-mountain...

Since every rock flower had once been near her, Wardon decided to climb down and search among the newly dropped load for more of her lovely friends. Close up, the rocks looked much larger than he had thought. There were several huge plates underneath the rubble. He pushed them aside and, indeed, found several more rock flowers, big ones, almost too big for his princess.

The upper slab was cracked and shattered into smaller pieces. He lifted one by one...

Oh my God!!! Wardon wanted to scream, but no sound escaped his throat. The giant skull! The empty eyes! Dark! Huge! The sorcerer stared at him out of the rock.

A mother and a demon

The fever attacked erratically. Nightmares tortured him. He spoke in his sleep and screamed. Night after night Wardon's mother sat at the edge of his bed holding his hand, drying his forehead, and soothing him. His father, the priest, cried over his son's possession.

A member of the Wens, he and his ancestors had lived for several centuries in Perca, a small village of the Central Range. Almost all male ancestors were priests of the Wen Faith. And demons and dark sufferings were no strangers to Wardon's father. He watched his son with knowing eyes.

After a week Wardon recovered and he found the courage to take his parents to his find in the quarry. When they arrived at the skull in the rock, Wardon's mother hardly looked at it. Watching her husband and Wardon made her understand immediately what lay at her feet. Oh, it was not what they thought! The demon was no longer in the stone. It would not help to move the rock. It would not help to bury it, either. The demon was already inside Wardon.

"Our forefathers told the story of the great deluge," she said firmly. "Many animals drowned and were covered with mud. This may be one of them. The mud may have hardened into rock over the many years, like mortar. We should look for more parts of this creature. Let's climb up and dig up the spot from where it fell."

The villagers were frightened by the find, and the quarry was no longer the home of humming insects in the heat, but a haunted place circled by their fearful and suspicious eyes. Yet, before they could act upon their thoughts, Wardon's mother had written to her brother Moshar, an Independent Judge of the circuit town of Oxassa who followed quickly his sister's urgent message. Moshar saw the skull and congratulated Wardon on his discovery. He spent a few more days in the village talking to the elders of the village. He explained that scholars at the University of the Central Range, and at universities of many other countries were increasingly convinced, that rock flowers were ancient plants that had been preserved over the ages by a process called 'fossilization'. He appealed to their knowledge of hardening mortar and the preservation of corpses in moors. The villagers should be proud to live near the quarry. The name of their village, Perca, would go down in history. Perhaps the creature would be named 'perca' after them.

Yes, Moshar was a persuasive speaker. And even if he did not convince many of the villagers, at least they left Wardon alone. After all, he had always been a freak, hadn't he?

A flower and a dark megalith

At the age of fourteen, Wardon spent two years in Oxassa. His memory of the cathedral of the giant pines faded gradually, and his dreams about the little rafts of pine needle seemed more childish now. He missed the quarry, though.

The fossil 'perca', as they called it, just as uncle Moshar had predicted, had made his village famous. Scholars from all over the world came to study it. Recently, it had been moved to the museum of Oxassa, skull, two legs, some ribs, one segment of the broken tail. They had even uncovered several bones of a deer underneath the perca.

The families in town were hospitable to the nephew of the Independent Judge. They loved his aristocratic composure spiced with a few grains of peasantry, and taught Wardon a few grains of bourgeois behavior that added to his amicable character. Oh, and the young daughters of the families! His gentle manners made him so different from the other boys. And his limp? Don't be silly! They adored it.

He returned to Perca as a different person. For the first month or so the other youngsters of the village listened to the wonders of Oxassa, how people lived there, how they dressed, how the young people danced. But after a while they returned to their former ways of life, and Wardon was alone again. There was one lovely exception, though. Llanoe, the daughter of Plicon, the violin maker, continued to encourage his visits by her smiles and her interest in his tales.

One summer evening Wardon and Llanoe strolled to the western woods near the so-called 'mother-stone'. Long, long ago, the ancestors of the giant sorcerer who had inhabited this area, had left megalithic structures scattered about. The saying went that the mother-stone had been the sculpture of an insane woman and her newborn child. Love made her demented gaze acquire a strange expression of insight. Her mind was unable to give the child, what her heart was aching to give. Her drooling mouth caressed its forehead. Unable to teach it any skills of survival, she could do no more than hold it close to her breasts, and rock it to sleep with garbled words and sounds. The other giants stood around and saw a cruelty of love they had never seen before. In their hearts rose great anger with the Gods. 'Never will we let you forget this', they shouted at the Gods. And with all their giant strength they erected the tallest slab of rock they could find, leaned against it a smaller one and carved into both the rune of the breaking heart.

When Llanoe and Wardon reached the stone, the setting sun seemed to set its top on fire, while dawn surrounded already its foot. Llanoe shuddered, and tried to pull Wardon away, but he stood arrested by a sound that came deep from within his heart. All of a sudden he felt that the insane mother was the truth of all living creatures. Terrified, Llanoe saw his eyes flicker in an alien face. She cried. Her tears broke the spell. Wardon laughed out loud and took her in his arms.

The water of dreams

The wall had caved in, the wooden planks over the old well were weathered and bleached by countless rains. Even in bright daylight, the cloisters were shady and cool. Some columns had collapsed, wild roses grew all over the arcs and covered the roof. The monks had left two centuries ago when the plague had raped the lands and their monastery. One by one they had died of the black death until there were only three survivors. They had buried the Sacred Scripture, the statue of the Goddess of the Wild Roses, and the Order's treasure and had left the valley. Nobody had ever found the treasure, but rumors persisted that it lay in the old well.

In the summer many young lovers like Llanoe and Wardon visited the old wishing well. It was impossible to see its bottom. Llanoe imagined all the dark creatures that were said to live below and to crawl out at certain nights of the year to hunt children. She was frightened to know them so near, but where else would wishes come true?

"How dark water can be", she said, " and how bright at other times. Have you ever imagined all the places where it can go?"

Wardon thought of the little creek in the pine forest. Its water had been riding the sky before it entered the dark silence of the giant pines, and when it emerged it was a glittering, foolish little stream, jumping over pebbles and swirling leaves around. So much like Llanoe!

He kissed her and for a while Llanoe's and his minds were less concerned with water and its fate. At last they separated, and Llanoe leaned back on the lawn. For a long time they were silent and listened to the humming and chirping around. The wild roses swayed in the mild gusts of the summer wind, and sometimes they could hear the dry scraping of a lizard's scales over the rocks.

The clouds above were swelling into huge towers. Their underside darkened. When the thunderstorm broke loose, Wardon and Llanoe rushed for shelter under the arcs of the monastery. Shaking the rain out of their hair they laughed at the sudden shower, huddled together and watched the rain splatter on the old yard. Some drops fell on the wild roses, some fell on the thirsty ground, and others fell into the shaft of the well, where the dark creatures drank the memories of the sky that the raindrops had travelled only moments before.

Magic of a flower

Gusts whipped the trees, dark clouds raced overhead at low altitude. Drenched and covered with mud, at other times Wardon would have found it impossible to walk. Not this time. He felt nothing.

Inside the grove of the giant pines the rustling of the storm suddenly ceased. Overhead he could see the giants shake their heads annoyed with the rough air, but down here the power of the storm was broken. Not even rain had reached the forest floor. He walked on the pine needles that were still dry. The lumps of mud fell of his shoes, and he walked lighter. The creek was swollen. He tried to leap over it, stumbled and dropped to the ground on the other side.

Was this the Gods' revenge for his love of her magic? There was no flower, no reflex of light that did not speak soothingly of eternity when she was with him. There was no past more comforting, no future more shining as when she spoke of time. In her company, the sun, the moons, the rocks, the waves, the birds, the trees, everything seemed to appear before his eyes fresh from the Creators' hands, still glittering and as if giggling at his bewildered gaze.

She was dying. Never again would she cast her graceful spells over him.

The creek swelled. The water reached his feet and began to wet his chest as he lay on the ground. He lay there, his head in a puddle of water, indifferent to the cold and danger of the rising water. A world without magic was not worth his struggles to live. Llanoe, Llanoe, Llanoe...

If she could not save herself, then there was no magic left in this world. Everything was just as shallow and brutal and mindless and arbitrary as it had always seemed to him.

Darkness fell and the only sounds left, were the rustling and whistling of gusts. He skidded often and fell to a muddy ground that he could no longer see. Suddenly, the storm was over. Silence spread over the land. The clouds opened and moonlight fell on Wardon. With crusts of mud on hair, face and clothes, the rain dripping from his coat, he looked up and shook his fist at the invisible, when he realized that he was lying at the foot of the mother-stone.

The murderer stirs

"It does not matter whether you comprehend the truth. Seek it regardless." said Wardon's father. Wardon sat with his parents on the rough hewn benches in their little orchard. The warm light of autumn shone through the colored leaves. The sky was distant and all the world seemed to stretch leisurely in the feeling of achievement. Wardon sat facing the sun behind the apple tree, and the slightest movement of the leaves made the light dance and flicker over his face.

Wardon's mother knitted while she listened to her husband's attempts to sooth Wardon's wounds with the teachings of the Wen Faith. She knew him too long to miss the meaning of his words. Llanoe's death had struck him hard, too.

All day long they had avoided to speak of Wardon's pending departure. Tomorrow he was to leave for Chabad to begin his studies at the University of the Central Range. His uncle Platoe who lived alone in Chabad had invited him to stay in his house. Wardon's mother hoped that Platoe would have a good influence on Wardon. A kind, balanced man with little ambition and much patience, he and Wardon's mother had liked each other from their days of childhood in Perca. Now he lived unmarried in Chabad and looked very much forward to having a son in his house for a while.

Suddenly, a strange dizziness fell upon Wardon. Where was his balance, his orientation? All the familiar things around him moved and swapped places. The world swayed. He tried to hold on to his chair, but fell. Then all of a sudden there was quiet again. He was horrified, and when his eyes met his father's he recognized the same fear. Only his mother seemed more startled than frightened.

"Is the murderer of the Gods already born?", she whispered huskily. "It is said that Swan-mountain will stir in its sleep when the murderer prepares to strike, and arise in fury when the Gods are dead."

The shining age

Wardon rose quickly to the top of his class. Teachers and fellow students liked the awkward, yet talented young man with his unusual views. Wardon in turn was awe-stricken by the cultured, refined, and knowledgeable people around him. They knew celebrities in person whose names had almost divine undertones for him. Artists, politicians, military leaders who seemed legends, were actually friends of someone he had met, or many years ago they had rocked his friend on their knees. No wonder, the friend could make good-natured jokes about them. What superiority!

And the beautiful houses! Some of his fellow students had invited him home. The yards, the marble staircases, the old furniture that had been precious from the day it was crafted! Today, centuries later these tables, chairs, chests and book cases gave splendid and reassuring testimony of the past. The casual manners of their owners made such an enticing difference to the heavy speech of his parents!

The people were interested in everything. 'Oh, this is the young chap who discovered the perca? Marvelous experience, to see that monster.' a father might say when Wardon visited with his son. And then he would turn to his son and add, 'Don't forget aunt Cannae's invitation tonight. And this time I want you to leave the Chancellor's daughter alone. You understand?' And again to Wardon, 'I wish I had a son like you. Your father must be awfully proud. This pirate here gives nothing but trouble. Incidentally, you must be a good hunter coming from Perca. You should join us sometime. Our cabin is not far from here'.

Their interests changed from year to year. At present, magnetism and fossils dominated their conversations. One person, in particular, had risen to fame in the course of the public fascination with the distant past: Lenner. His grandson, Celtis, was a class-mate of Wardon's.

At first Celtis had appeared aloof and even arrogant. No wonder, the offspring of an old family that had brought forward many distinguished scholars, priests and artists, knew everybody, had access to everything, and it showed. Soon, however, both discovered that a limping, deep-rooted, heavy-minded peasant and a witty, not impressionable, cheerful son of the cultural aristocracy were a perfect match. Celtis' parents were pleased with their son's choice of a friend and encouraged Wardon's visits to their house.

During one of their study sessions in Celtis' garden, Wardon met Celtis' grandfather, Lenner, an admirable man with a distant, silvery dignity. He expressed his pleasure of meeting his grandson's friend and at the same time the discoverer of the perca.

"Actually, we met already" he said to Wardon." I was one of the first visitors to Perca after your discovery. I remember you quite well as a shy boy.".

"This might interest you", he added and pulled a plate of shale out of his pocket. Wardon and Celtis looked at a perfectly preserved little crab in the stone. Although the sight touched certain fears somewhere in the back of Wardon's mind, he was fascinated by the delicacy of the fossil.

"It looks like one of Aunt Millie's watercolors, only less pink." joked Celtis.

"This crab," explained Lenner, "like your perca lived in swamps. When it died, it sank to the bottom where the mud preserved it. Over long periods of time more mud and silt piled up on it, and perfused it. Eventually, it hardened like mortar and thus kept it in stone. The same happened to the perca you found. It died a natural death and sank to the bottom of a swamp."

The mud-theory raised some queries in Wardon's mind. The carp pond in his village was drained every five years in order to harvest the fish and to clean out the mud. As far as he could remember the mud had never contained any preserved animals, but who could base conclusions about fossilization on an experience with a carp pond?

Still, the thought of the dying perca sinking slowly to the bottom of its swamp suggested something soothing to him; a graceful, slow floating and soundless burial. How could he ever have sensed terror and violence and be frightened? How wonderful the clarity of knowledge and science and how privileged he was to know a scholar and scientist like Lenner!

He opened his mouth to ask Lenner about the carp ponds, when Celtis interrupted him.

"Ask grandfather any questions, and I kill you. He won't stop for the rest of the afternoon."

"I wish that certain grand-children of mine would have a sufficiently inquisitive mind to find out, for example, what kind of clothes one wears on a trip." said Lenner.

"Oh my God!" Celtis held his hand to his mouth. "I forgot entirely. We are leaving in a month, aren't we?"

"Yes, " said Lenner with a mixture of sarcasm, reproach and love. Then he turned to Wardon. "Would you like to come along? There is enough room on the 'Alcatroose', and it will be very exciting." He saw Wardon's questioning eyes and added, "Surely, Celtis must have told you that we travel to the Carpenter Islands to a newly discovered site of fossils."

No, Celtis had not told him, and it did not take much persuasion to overcome Wardon's reluctance. Thus, on the fifth of Ladender eighteen hundred and seven they set sail on the historic trip of the 'Alcatroose' that would give the world the theory of the 'Origin of Species'.

A giant vision

The fossil ground on Plana, the western island of the Carpenter archipelago was rich and mysterious. Lenner was in his element. With great vigor and neglect of his age he dug, cleaned finds, and oversaw the native workers. Celtis worked next to him and learned the finer details of fossil hunting. He seemed genuinely interested, and his tanned, dust-covered face, laughing and joking among the natives was pleasant to watch.

Wardon increasingly disliked the site. The more they dug, the more it reminded him of the quarry. Old fears awoke as he watched the people wound the ground. Lenner sensed the strength of Wardon's aversion, and restricted his involvement to the sorting and cataloguing of the finds. His duties left Wardon much free time, which he spent exploring the island.

The splendor of one place in particular, called the 'Devils Throat', attracted him. It was a dark lake at the bottom of a steep crater near the shore. Often, he wandered alone through the forests to Devil's Throat, remembering the cathedral of the giant pines of his childhood. He liked to sit at the southern edge of the abyss and look down to the mysterious circle of greenish-black water shimmering deep below. With the sun in his back, the white rocks of the opposite wall reflected such blinding light, that he had to cover his eyes, in order to see the ocean beyond the rim of the crater.

The crater was not volcanic in origin. Lenner had explained it, how in prehistoric times an earthquake had separated the bay from the open ocean by an up-heaving ridge. It unleashed a gigantic rock slide from a mountain nearby. The odd, concave scar in the mountain slope next to the crater was still recognizable, and Wardon could only guess how high it must have been before nature had used its top to reinforce a natural dam against the open sea. By now the lake was no longer a place of devastation. Vegetation and erosion had turned it to one of the most spectacular sceneries, Wardon had ever seen.

On the now famous historical day he had walked to Devil's Throat as so often before. He sat at his favorite spot and dreamed. Every so often he dropped a stone down to the lake and counted the seconds until the sound returned. He wished that Llanoe could be with him.

In contrast to the wishing well in the old monastery, the Devil's Throat, indeed, hid strange creatures in its dark depths. Once the natives had caught one and showed it to him. It was a flat, pale ray with extremely long tentacles and a hypertrophied back fin. Wardon had wondered how such a creature could swim at all, let alone escape from predators or hunt prey. Lenner had explained to him that the Devil's Throat was the only place where they existed.

Would Llanoe have feared them? Admittedly, these rays did not leave the lake at certain nights of the year in order to hunt for children, but the natives told gruesome stories about them, nevertheless. For example, there was a man who tried to row his boat across 'Devil's Throat' in an upcoming thunderstorm when the waters around him began boiling with the white bodies of countless rays which began to jump into the air and glide for a distance. They tumbled in the upcoming gusts and many landed in his boat, until it capsized. He was never heard of again.

The rays were not the only unique creatures of the lake. There were crabs with snail-like tails that enabled them to swim and dive deep for food; there was a unique type of carnivorous underwater weed. Yet, many other animals and plants were quite normal and existed in other freshwater lakes as well.

Wardon stared at the dark depth of the lake and thought about nature who sometimes permitted freaks like these rays and like himself to survive, whereas most of the time she made sure that they were killed. Yet, he began to realize that the freak rays would never have survived if the earthquake and the gigantic rock-slide had not killed countless animals and plants and cut the survivors off the bay. After the rock-slide, however, the predators, well adapted to the hunt in the open sea, were ill-adjusted to the freshwater lake, that had become of the former bay. He knew from his own life that a catastrophe is more devastating for the normal majority, than for freaks like himself. They could handle hardship. Their life has been a string of catastrophes all along.

Strangely incoherent thoughts began to storm his mind, which soon ordered themselves into an overwhelmingly logical pattern. The day when he found the perca returned to him. The shock, the fears, the nightmares that had sent him, the limping freak, away from the sleepy village of Perca, and around the world.

Presently, the scene changed, and he saw the day when Devil's Throat formed. He shuddered at the violence of the earthquake, the tidal waves that relentlessly smashed countless creatures to their death at the face of the rocks, the thundering of the rock-slide as it cut off the bay and buried even more sea creatures underneath! How could nature, the all-giving, all-loving mother of these creatures act so insanely?

At this, another insane mother appeared before his eyes. While his mind relived the death-cries of the innocent creatures drowned by the thunder of the rock slide, he recognized the fallacy of the story of the giants. Suddenly he understood the true reason and the extent of their wrath, as they had been forced to serve the most insane of all mothers. That was the meaning of the rune of the broken heart carved into the mother-stone: It paid honor to the countless perfect creatures that the giants had been ordered to destroy every time when nature, the insane mother had wished to create shelter for a new freak.

Half a planet away, the mother-stone had reached out for his heart. The ancient knowledge of the giants had found its prophet. The giants, the instruments of the ruthless, insane, chaotic motherly God, of nature herself, who had been ordered cruelly time and again to use their powers for destruction against their will, had finally found their avenger. Wardon would toss all Gods into oblivion. Nature was not divine. Creation was not the work of Gods. It was the work of blind catastrophe.

A case for the runt

People were standing in the aisles of the lecture hall. Wardon's book, the 'Origin of Species' had caused world-wide controversy. Even nationalistic undertones had entered the discussions about the evolution of animals and plants as tensions grew between the Northern Province and the Central Range, Wardon's home country.

Today's debate in the main lecture hall of the University of the Central Range at Chabad was intended to argue the major two alternatives that had emerged in the past discussions among academics.

One position, argued by Wardon himself, suggested that new species arose as natural catastrophes gave shelter to freak organisms as they killed the majority of normal creatures. The other position was argued by Pillit, a highly educated, brilliant scientist who had distinguished himself among the adversaries of Wardon's concepts. He insisted that there was merely not enough knowledge available to consider the origin of life at all. The third position, held by the public at large, namely that the Gods had created life, was not discussed at all. Scientists on either side of the fence had no intentions to include Gods in any of their arguments.

Wardon was about to end his statement.

"... there is an obvious mechanism to conserve and stabilize the design of every species of organisms. The latter mechanism consists of two parts. One is the mechanism of inheritance, and the other is the perpetual struggle for survival of all creatures. This struggle weeds out the deviating individuals of a species, and leaves only the normal, adapted individual alive.

Consequently, the mechanism that had improved the design of organisms over time must have overridden the two stabilizing mechanisms. At what occasions does it override? Obviously during natural catastrophes. How else should circumstances be called, that allow large numbers of offspring to survive which would have been unfit under normal circumstances? Therefore, I have suggested that natural catastrophes create new living conditions, and shelter runts at the same time. Hence, deviating organisms receive a chance to reach adulthood and to proliferate. The normal forms of the species that competes for food and other needs with the variants may be eradicated or at least severely decimated by the catastrophe. That is how change comes about."

He sat down. There was enthusiastic applause from one part of the audience, while the other part maintained icy silence. Pillit got up and went to the rostrum.

"I find it difficult to respond to the propositions of my learned colleague." he began. "There are too many ad hoc assumptions, too many different propositions, too many gaps in our knowledge to decide either way. In contrast to jurisdiction, science cannot give the benefit of the doubt. Is there room for doubt in the statements of Dr. Wardon that catastrophes produced ever improving organisms? Of course, there is more of it than time permits me to discuss. Let me therefore focus on a few salient points of his concept, that must be contested and in my opinion rejected, as well.

Firstly, his use of the term 'catastrophe' lacks the necessary accuracy for a scientific definition. For example, he does not specify which kind of catastrophe will give lungs to amphibians, which kind of catastrophe gives wings to birds? Do volcanic eruptions always enlarge fins and turn carnivores into plant-feeders, and if so, why? I see no logic in that.

Secondly, if we accept his mechanism for the moment, how can the survival of the runts improve the species? In my opinion, it would deteriorate it. " There was spontaneous applause in the audience. Pillit continued.

"Thirdly, Dr. Wardon does not specify the amount of time required for the transition from a primitive organism to man. How long does it take just to develop wings for birds? I realize that nobody can answer this question, but the burden of proof is on the proponent of the concept. Otherwise, he has no concept to suggest.

"I should like to elaborate a little more on a fourth point. Dr. Wardon suggests that weeding out the runts is a mechanism to stabilize the design of a species. Without trying to commit the same mistake as Dr. Wardon, namely to suggest prematurely a mechanism of evolution, couldn't it cause the opposite? Wouldn't the weeding out of the runt favour an organism that is accidentally improved over the others? Couldn't the normal majority be considered as a runt compared with a new organism? Unfortunately, the 'weeding out of the runts' does not specify satisfactorily, what a runt is. An evolving amphibian may be a runt for the fish, but a superior design in the overall picture of nature." This time the applause was very strong.

"Finally, we do not know how old the planet is. We do not know when life originated. We know very little how organisms work. How can we claim to know how they changed and improved, if indeed they did?" Roaring applause arose among Wardon's adversaries, while Pillit returned to his seat.

A demon's exorcism

Wardon remembered his father's words. Be the prophet of a big cause, or be no prophet at all. He knew that his cause was big. It made him humble and yet, there was no need to bow. Bowing people do not see much, do they?

Wardon felt no longer inferior to other people. No power was either irresistible or illogical. The powers of chaos were resistible and logical, or else there would be no life. Life's powers were resistible and logical. Otherwise there would be no death. Even death was resistible and logical. Life proved it. Thus chaos, life and death resisted and created each other. Only freak organisms could thrive in such a paradoxical world. Only freaks were aware and enduring and courageous enough to survive. The weak could not afford the narcism of the perfect creatures. While he reflected on himself, forces outside might gather and strike beyond his poor defenses.

Paradoxes begat more paradoxes: A freak organism who became successful through a catastrophe, turned into one of the perfect ones, that in turn might fail during the next catastrophe. Wardon was exhilarated by the further paradox of his theory. Nature simply disliked completion. It was part of her insanity, that she lost interest in completed works, no matter how perfect she had created them in her sane times. Perfection was only the beginning of destruction.

Wardon rose to respond to Pillit's criticism. "I can be brief", he said. "Let me answer the objections in the same order as my esteemed colleague. Firstly, I never claimed that there were specific catastrophes for specific changes in the design of an animal. Yet, it is obvious that volcanic eruptions will favor runts that can exist in very dry or very wet environments, and that need less light from the sun, at least until the volcanic dust clouds have cleared from the planet's atmosphere. Likewise, floods will favor deviating animals that can live in murky waters, an so on.

As to the objection that my proposed mechanism of favouring runts should deteriorate rather than improve a species, I agree that it can. If it does, then the species eventually becomes extinct as a delayed casualty of the catastrophe. We must assume, however, that the opposite can happen as well; that the runt which has received a new organ or ability that is favoured by the post-catastrophe world, will eventually give rise to a new species.

My colleague raised the difficult question about the time required for evolution. I don't know the time expressed in units of years or hours, but I know how to expressed it in units of geological strata. What is wrong with measuring time in units of strata? It is as much an arbitrary measure as the number of revolutions of the planet that we use as units of time. Some day, I am sure, we shall find ways of dating the strata in units of years, or millennia. For the time being, however, it is quite legitimate to use it.

Dr. Pillit pointed out that killing runts may not be a suitable mechanism to stabilize the design of a species, as I had suggested, but may in fact be a mechanism of improving the species. This suggestion is very interesting, and I do not deny that at one time or another an accidental change of an animal may be favorable. Better adapted to its environment, this runt may have an improved chance for survival over its fellow species members. But this is exactly how I would perceive this mechanism. As a mechanism of better adaptation of an existing species, rather than a mechanism that creates entirely new ones. Just imagine a fish with rudimentary lungs that hamper its normal breathing, outnumbered by normal ones! Without a catastrophe improving its odds of escaping its predators, it will never survive on dry land.

Finally, a general remark to Dr. Pillit, as he so kindly lectured me on the ethics of science. I disagree strongly with his notion that science has to reject what is not yet proven. On the contrary, the unproven thought is the intellectual runt, that is the impetus for progress. It sparks vision and drives scientists to examine nature in novel ways. Without daring ideas, science will not grow. As in the case of the evolution of life on this planet, the weak, the freakish, the unproven is our only hope for progress. I don't know what special kind of 'catastrophe' will move the minds of my colleagues towards a more daring concept of science, but I hope that it will not have to destroy our heritage of science."

Wardon's face expressed the fatigue of victory. Reason had finally driven out the Demon, but the Gods were dead.

Prophecy

Presently, Swan-mountain rose from its sleep. A boiling black wall cracked by lightning enveloped the surrounding land in destruction beyond human memory. Faster than hurricanes, hotter than geysers, harder than rock it crushed everything in its way. Millions of voices screamed in death, and fell silent under thick layers of dust.

Perca was gone in an instant. It took only seconds to flatten and bury the house of Wardon's childhood. The walls of the monastery crumbled, the well collapsed. The mother-stone tumbled, rolled down the slope and shattered. Every giant pine in the forest was crushed flat on the ground upon the first impact of the dust-laden air. An earthquake tore open the quarry and fossil creatures much older than the perca briefly sprung to a gloomy light before they were scattered and covered again with dust and mud.

By comparison with Swan-mountain's past, the present eruption was a minor episode. Yet, it took months before the roads leading to the valley of Perca were cleared enough to permit travel to the site of the devastation.

Wardon was among the first to stand on Bell-mountain at the mouth of the valley. Grey death stared up to him. The old man cried. Pain and anger shook the father of the 'Origin of Species', the prophet of our insight into the distant past of the planet. Somewhere down there lay his parents and Llanoe in their graves. Lost forever. Wardon knew that he was soon to follow them.

THE ODD GIANTS

The wall of ice

"It is my pleasure, to introduce tonight's speaker, Dr. Menda You all know her as the discoverer of two elements and the originator of the system of elements. This is a remarkable record for a single scientist. I may add, that we are all very proud that her work has been carried out at our College. In fact," Bok smiled at Menda who sat nervously in the first row waiting for him to finish the introduction, "Today is a rather special day for the College and for Dr. Menda, and -" he paused, "- for myself."

"On this very day twelve years ago, the mother of a diffident young girl sat in my office and tried to convince me that the girl was better placed in an art class. With due respect to my esteemed colleagues from the Art Department, I am glad it didn't happen." There was polite laughter in the audience. He looked again at Menda. "It was twelve years ago, wasn't it?"

Menda hated the warm-up phase of a lecture where she had to break through the jumble of concepts, prejudices and unrelated thoughts of the audience in front of her. Ten minutes or so later, she usually captured their minds, dispersed their stray thoughts about her looks, size and sex, and raised their curiosity about the topic.

There had been times, though, when she failed, nightmarish times, hard to forget, deeply depressing for days. The torture was, to know failure and yet to be forced to continue the useless and painful exercise for another hour.

The present one was to be one of the most frightening seminars of her life. When Bok had told her about the promotion committee's request for a seminar, he had also urged her not to speak about her pentomino concept. He had pointed out that the seminar was a formality, and that she had more than enough material to present without discussing the question why there were twelve elements. Yet, how could she be silent about a vision that filled her mind with joy and certainty?

"Yes," she answered Bok's question with a whisper. Expecting only to listen to introductory phrases, she had difficulties to answer.

"Well," Bok continued in seemingly good spirits, "we are all looking forward to many more years of work of such a distinguished scientist at our College." It sounded like a threat to the members of the promotion committee. He gave an inaudible sigh, before he continued.

"Tonight Dr. Menda will present to us an entirely new concept that she has developed from her studies of the atomic weights. It is a revolutionary concept. And we are all anxious to hear it." With a gesture of introduction he added, "Dr. Menda."

Menda collected her notes and climbed up to the podium. "Thank you, Dr. Bok," she began." At this anniversary of my enrollment at the College I should like to thank the College and in particular Dr. Bok for the education and support that I received here. " She paused briefly and then went right to the point.

"I hope that this presentation will do justice to my feelings of gratitude. It will be more philosophical than experimental. I don't mean this as an apology. Of course I am aware that the main thrust of science is not to speculate about nature in one's own mind, but to go out and examine her. Yet, we all know that deduction alone cannot order our empirical knowledge. The premises from which to deduce have to be formulated first. In order to find them we must employ induction. visions, if you will."

That wasn't going well. She was too verbose. The audience was not following her. Somebody waved salute to a friend across the room. She looked briefly at her notes. 'Precedence of Astronomy', it read. "For instance, one cannot deduce the planetary movements, without first having assumed the central position of the sun." she continued. "There is no proof as yet, that the sun occupies indeed the central position of the planetary system, and yet, we all agree that any other model of the solar system is unthinkable. Why? It is because the model explains simply and completely the complexity of the planetary movements. Tonight I must ask you to apply the same type of reasoning to the phenomena of atomic weights and atomic associations."

Two late-comers stirred up the last row as they moved to a seat in the middle. Bok did not look at Menda who was studying her notes again. He could hear Zerk's sarcastic voice remarking how glad he was that she had finally explained to him the significance of her work. Let's not be too modest about it! Two hundred years of astronomy and her neat little speculation were in the same category, weren't they?

"The most puzzling question of science today concerns the number of elements. Why twelve? Some of you may answer 'Why not?'."

There was a slight murmur. The audience seemed pleased, although the little joke did not help much to break through the wall in front of her.

"It seems futile to ask why there are nine planets in our system; it may be as futile to search for an explanation for the number of elements. However, there is an important difference. If we assume that the number of elements arose as accidentally as the number of planets, then we have to ask what events underlie the accident of twelve elements? Wouldn't these events belong to a level of Nature more fundamental than even elements?"

Somebody interrupted her. "Why do you assume that there are twelve elements?'

"I was about to discuss this question." She replied and presented her arguments that the periodic system of elements was complete. Obviously, they were not impressed.

Some of her strongest supporters in the audience showed strain. Completeness must not be argued, but be demonstrated experimentally.

"Although we have no rigorous way at present to exclude the existence of a thirteenth element, let us assume for the moment that they do not exist, and ask again how we can explain the number twelve. "

Come on, Menda! We can play little intellectual games just like you. We did not come here tonight in order to listen to yours. Two people got up and forced ten others to let them squeeze through the row. The disturbance irritated Menda. She had never walked out during a seminar, no matter how bad the speaker was. What upset these people? What kind of fear?

"Again we must resort to the principles of simplicity." She felt weak. The arguments for the completeness of the system of elements were strong compared to what was to follow. Her power of persuasion had to enthuse the others. And she was losing it. She grew less convinced, that the audience would understand the beauty of a world created from single cubes that grouped themselves into all twelve possible flat shapes of five. Her voice grew lower.

"Could you please speak up a little. It is very difficult to hear you." A voice shouted from the back of the lecture hall.

Menda tried to raise her voice. In vain! She had to explain a level of mystery that one cannot yell across a room. Paging through her notes, she was tempted to stop this lecture here and now.

Vision of ant-hill

Nobody before Bekkel had found it strange, that substances reacted with one another at constant ratios: If a certain amount of substance A reacted with another amount of substance B, then twice as much A reacted with twice as much B and formed twice as much product. Although there seemed to be exceptions, Bekkel and his students set out to determine the reaction ratios of all known substances.

Within three years they compiled a long list of data and eventually began to organize them into a book. Weeks and months passed. Tables and graphs were designed, discarded, redesigned and compiled into larger formats.

The first surprising fact to surface from the work was the large number of substances that reacted with integral amounts of irat. But Irat was not the only substance with this property. Among the data Bekkel found a total of seven, that reacted with others in ratios of simple integers. Boldly, he suggested, that these substances were more fundamental than others. He called them "elements", and suggested that all other substances were composed of various amounts of them. He argued, that there was only one way to explain the integral amounts of reactants, namely by the existence of smallest, indivisible units which he called "atoms". Consequently, he suggested that each substance consisted of many, many molecules, which were composed of N atoms of one element, M atoms of another, and so forth. The atom-theory of matter was born.

His opponents were quick to ridicule his approach, but Bekkel was not discouraged by the criticism. It remained frustrating though, that he was unable to explain the fact that particular integers described how many atoms of a substance reacted with the atoms of another.

As the story goes, one day he was watching an ant-hill. What ever comparison he may have made between the futility of his efforts and that of theirs, all of a sudden his eyes were caught by a train of ants carrying a caterpillar and pine needles to the nest. He began to count. There were always three ants carrying one needle and ten ants carrying one caterpillar! That was it: The atoms had special sizes and shapes and they stuck to each other according to the available space. How simple, and how ingenious of nature! All the complexity of this world was the result of atomic shapes fitting into each other.

The encounter of the legends

Menda met Bekkel only once. The Eastern Continent had organized a symposium on "Elements and Their Role in Nature" in Ro'alam, the capitol of the Northern Province. The old Bekkel had come, and everybody was eager to catch a glimpse of him. Menda did not present a paper, but at the evening reception she found herself suddenly face to face with him. His eyes were kind, but did not seem to focus on anything any more. His white hair was disordered, his back was bent. Menda stepped aside to let him pass, and for a brief moment their eyes met, as he nodded to acknowledge her courtesy.

The symposium was meant as an honoring gesture to Bekkel. After years of struggle and rejection it should have been gratifying to see the world acknowledge his work in this way. Yet, in the past years he had become quite withdrawn. There was no bitterness or pain in his silence, only peace and kindness, which were nevertheless impenetrable barriers. Maybe the suicide of his son was the reason. Maybe minds like his always developed toward silence.

The symposium had made it clear to everybody, that natural elements existed. Ten had been discovered. At least one, perhaps as many as four more were expected to be found shortly.

It had its disappointing aspect, too. Bekkel's shape theory of atoms remained unproven. His opponents, no longer able to attack his concept of elements, focussed their criticism on the shape theory. No microscope was powerful enough to image single atoms, and no indirect method could demonstrate convincingly that the association between atoms depended on their shapes. Voices grew louder, demanding that Bekkel should come forward to identify the shapes. Near the end of his life he was unable to prove what he had called 'his most important thought' and was forced to let his opponents triumph. Yet, he knew that the truth never wins opponents; it wins centuries. Thus, with polite interest he listened to speakers who urged to shift the emphasis away from the search for more elements. Instead, they suggested to intensify the research into the properties of the known elements.

Menda disagreed with them. She was certain that the search for the elements had to be completed before any attempt could be made to formulate a relationship between their macroscopic and their microscopic, atomic properties. What good was it to construct theories about a number of objects that was as small as ten? Sure, they explained the properties of ten elements until an eleventh, twelfth... came along and destroyed the concept. Ten was too small a number to distinguish between the possible hypotheses. Knowing the total number of elements would add a decisive restriction to the criteria that distinguished between good and bad theories.

She returned from the meeting determined to complete the search. One year later, she discovered the eleventh element "teat". At the time it caused little sensation among scientists. They were too busy measuring the specific gravity, surface tension etc. of the known ten elements, and were more excited about an apparent relationship between the viscosity and the color of six of the elements. Nevertheless, the discovery caused the College to offer her an Assistant Professorship.

Sparkles and the fear of death

Call, the Dean of Passol College and a friend of Dean Bok's was visiting Menda's laboratory. When Bok had told him of Menda's latest discovery, he was surprised at Call's strong interest in her invention of a plasma-balance.

Call never tired to include brilliant ideas and methods of others in his project. As a composite of the best achievements of his time, his work had to rise above them and thus bring him closer to his dream of a National Award.

The National Award was the highest international distinction, given annually to two recipients by the Congress of the Central Province. It retained its name from the last century when the Central Province had awarded annually two of her citizens for achievements in the fields of medicine, art and mathematics. Responding to criticism of parochialism, twenty years later the Congress decided to make individuals from other countries eligible as well. Around the turn of the century a National Award for the new field of science had been established and, of course, one of the first winners had been no other than Bekkel.

Many years of awards to some of the greatest minds of the time had bestowed such a large prestige upon the National Award, that winning it was no longer perceived as reward for achievements in a field, but as a goal of the field itself. Inverting cause and effect, Call admired the work of laureates on the grounds that they had received the Award. He could not imagine a higher climax of his life, than to receive the honor of the award before the eyes of the world. Menda, and many like her were supposed to pave his way.

"It is very easy to measure the weight of materials in the plasma-state," explained Menda. "because, they all have the same volume, at the same pressure."

"This has never been shown," objected Call.

"No," said Menda," but I think, I have the evidence here."

She went over to the apparatus near the window.

"This is a high pressure balance that can be heated to bring most substances into the plasma-state."

She turned it on.

"It will take a minute or so. In the meantime I weigh out 3.4 units of irat."

Call's interest vanished. He did not know whether to be merely bored or to be offended as well. How could Bok bring him over for such a childish demonstration. Everybody had seen heated matter melt, evaporate, glow and then turn into the state of intermittent light emission. This so-called plasma-state was fun for students. They loved to watch the sparking of space that had seemed empty only a moment ago. They loved it even more, when the demonstrating teacher accidentally let plasma escape. Then a crackling cloud danced unpredictably in mid-air, while the teacher tried to catch it. Call was sure that he did not need another demonstration.

"Don't bother." he said. "I take your word for it. So, you say that the same pressure results, if you add a certain amount of material to your contraption. No matter, what the substance is."

"Not quite," said Menda. "If the substance is an element, I get the same pressure. Otherwise I get integral multiples of the pressure, that an element would have produced."

Call's interest returned. In the past year, several chemical manufacturers had approached him about an inexpensive test for the purity of a product. If Menda was right, her little machine could measure the pressure of the product in the plasma-state and thus determine the amount of contaminants. Such a method could mean considerable wealth. A number of technical questions had to be answered first. Was it necessary to dissolve the material? How long did it have to be heated? Could it be heated and cooled several times in a row? What was the minimal amount that could be measured?

Menda answered as well as she knew. She grew more and more restless. She wanted to explain, that constant pressure and constant volume meant constant number of atoms. In other words, the atoms of every element had the same weight.

Therefore, it meant that all atoms were made from the same unit amount of material - even atoms of different elements. But if that was so, what made the elements different? If not material and amount, it had to be their shape. Bekkel was right. The Gods had cut a primordial substance into tiny pieces of equal amounts. Then they had molded them into eleven, perhaps twelve different shapes that combined and formed the diversity of the world.

All that was lost on Call. His mind was occupied with the purity test that he had just now conceived. He nodded politely to Menda' s words, but she knew that he did not listen. It was just as well, because he would have been bewildered at best.

After he had left, Menda thought about the barriers that prevented people like Call from ever achieving their dream of greatness. Too appalled by the chaos that inevitably preceded the creative acts of great minds, they close their eyes to every new thought. Like children who are fascinated by monsters, they drive themselves toward creativity, only to run away from it.

Colored pairs in the sun

The day on which Menda discovered the periodic system of diatomic elements began as a glorious autumn morning. After the rising sun had dissipated the fog, the campus revealed itself in ever more saturated colors. After a few unsuccessful attempts to begin her work, Menda realized that she had to choose between the library where no warm sunlight could distract her, or a work-free morning. She chose the latter. Strolling across Bekkel-Square she joined a stream of students and faculty, who had followed the same calling.

The newest fashion among lovers dictated to wear clothes of the same color. Thus the colorful currents and counter-currents of this morning's sunlight-seekers all across campus contained many double-patches that floated, tumbled, swirled, yet never came apart. Menda sat on the little stone wall on the northern corner of Bekkel-Square, basked in the warm sunlight and watched their spatial constellations. Regardless of the particular pattern of the two lovers' clothes, from a distance they were simply red, white, blue, yellow or green.

Was it was the hypnotic power of the sunlight, or a little residue from last night's sleep? Her eyes were unable to focus on individuals, and increasingly the streams appeared to be composed of strange compounds that were grouped and ungrouped by certain laws of association. 'Man has no individuality', she thought. 'It is a trick of nature, to make us accept responsibility for parts of a larger being'.

In her present state of mind, the unicolored double-patches took on a special significance. There seemed to be a never-ending dance of singles who blossomed into color when united in pairs. Seeing all the pairs, colors, whirls and streams in the sun, she saw no higher goal than to join them and lose herself, when she remembered her afternoon lecture. She got up from the small spot, that had become so familiar this morning, and walked back to her study, albeit still a little light-footed, and light-minded for that matter.

Back at the desk she tried to put her mind to the lecture, but the color swirls of the frivolous pairs of lovers refused to go away. She could not resist to draw little colored pairs with the symbols of the elements.

'A yellow pair of nat,
a purple pair of vat,
the parat pair,
the lavat pair,
are blue beyond repair...

her thoughts sang happily, while she tried to put serious lecture notes on a sheet of paper.

All of a sudden she was sober.

There it was! Do not look at single atoms! Look at pairs! In the diatomic form certain elements had identical properties. As a result of their similarity they co-purified if they had the opportunity to enter the diatomic state.

Menda wrote down the elements that co-purified and saw that they ordered themselves in an amazingly simple way: There were four groups, with three members each. Why had nobody noticed before, that diatomic nat, turat and irat were indistinguishable? 'They formed one of the groups. The second group consisted of teat, vat and lavat, that were indistinguishable in their diatomic state as well. The third group contained douwat, corat and parat with identical properties of their diatomic form as well. The last group was incomplete. Diatomic zalat and exat were very similar, although she had to admit, that diatomic exat and zalat did not co-purify.

If the implication of the system in front of her was correct, then there should be a twelfth element in the last group that was identical to zalat or exat in the diatomic state. It should be a contaminant of preparations of either elements.

Armed with these predictions of its properties, she set out to find it. Two months later, she found it in preparation EEx-14b. In memory of the warm morning on Bekkel-Square, she called it "starat". Thus the periodic system of diatomic elements was born.

Subtle shackles

Rarely had the faculty received stronger letters of recommendation. Hulle was everybody's favorite, and Menda saw no reason to object to his appointment, either. Like Bok and many other members of the faculty, he was a Wen. He was proud to belong to a people who had produced so many distinguished scientists, including Bekkel.

GROUP	ELEMENT 1	ELEMENT 2	ELEMENT 3
I.	NAT	TURAT	IRAT
II.	TEAT*)	VAT	LAVAT
III.	DOUWAT	CORAT	PARAT
IV.	ZALAT	STARAT**)	EXAT

*) discovered by Menda
**) postulated and subsequently discovered by Menda.

Hulle won everybody's heart. He was handsome, friendly and serious. Menda loved to watch him turn from a sun-burnt mountaineer to a scholar simply by putting on his glasses. Unlike many handsome people, who consider themselves invited to everybody's world while excluding others from theirs, he actually expressed some self-consciousness, although in a good humored way. His manners did not suggest that he considered his colleagues' scholarship as a poor substitute for his physical gifts.

As a senior post-doctoral fellow he ranked below Menda, who had been an Assistant Professor for two years. In addition, her discovery of the element 'teat' had earned her notoriety among scientists, while he was still unknown. He sought her advice and help, which she was happy to give. When promotion time came, she supported him strongly and convinced the faculty, that he was ready for an Assistant Professorship. She cited his success with students and expressed great enthusiasm for the potential of his project of superheated plasma that ought to give entirely new insights into the nature of atoms. The project was actually her idea, and Hulle had simply followed her guidance, but she gave all the credit to him, and soon after Hulle became Menda's peer.

Women were not allowed to join the traditional afternoon tea at the Faculty Club, and so Menda had tea in her laboratory. For a man's career, the exclusion from contact with influential people would have meant certain disaster. Since women were not expected to have careers, the men on the faculty tacitly assumed that Menda was not interested in the tea hour, because she had no use for it. The extent of the offence did not occur to them.

Normally, Menda would not have cared. She had little inclination to join any club or group, and was too absorbed in her work for social games. In addition, they were right, she never expected to rise above the level of an Assistant Professor. Yet, her exclusion from the tea hurt for a different reason: It deprived her of the opportunity to see Hulle. As it were, seeing him required special efforts that could draw his attention to her feelings. Only the library and the departmental seminars offered her occasional encounters which could not arouse his suspicion. Of course, Hulle visited her laboratory from time to time, when he needed advice and criticism, but these wonderful occasions happened only too rarely.

There was one other possibility to meet him casually. Weather permitting, Hulle often took his lunch to a certain bench on Bekkel-Square. At noon time on sunny days she was irresistibly drawn to stroll along the Square in ever narrowing loops around 'the' bench. But, all to often, she suffered bitter disappointment when a stranger was sitting there!

She envied the men on the faculty who were allowed to meet him almost daily at the tea room, to see his handsome face and to listen to his lively voice. She envied them for enjoying his boyish smile when he interrupted serious debates with irreverent, incredibly funny remarks.

Hulle's expression and attentive manners in her presence left no doubt that he was fond of her and admired her. Yet, she could not expect anything more. Not only was she two years his senior, but she was not a Wen, and the Wens were traditionally obliged to marry among each other. Besides, a handsome man like Hulle was the prized company of elegant, attractive women with whom Menda could not compete, anyway. She had no delusion about her appeal to men.

All of her shy heart's desire was to be in his company. How much she dreaded Fridays knowing that there would be no opportunity to see him for two full days! On rainy weekends she felt less lonely, because he, too, was most likely sitting at home and reading. However, she ached when strong winds and sunny skies populated the lake with glittering sails. One of the sails was his, and she knew that he was out there laughing at the gusts and giving his attention and charm to a self-assured, beautiful young woman. At least she imagined so.

Whenever Menda met Hulle in the company of one of his lady-friends, he did not fail to introduce her with politeness and respect. She noticed their amused smiles when he boasted a little with her fame and achievements, as if they were asking, 'Isn't it adorable, how little makes him happy?'

They seemed to have little regard for science, but accepted it in order to humor Hulle. Besides, his scholarship tempered his charm with gravity and added a hint of inexperience which distinguished him from other, equally good-looking men, who were often a bit too sure of themselves.

Recently and happily, his visits to her laboratory had become more frequent. As his project required Menda's plasma-chamber, she was delighted to train him in its use, and to discuss the experiments with him in detail. These afternoons were golden and unforgettable. Hour after hour she relished his undivided attention. The afternoon sun shone through the open window, and the cheerful voices of the students walking below on Bekkel-Square sounded up to her room, while he paced up and down, debating, arguing, laughing from time to time, turning serious again, but all the time being with her.

Science was simply incomparable. There was no higher, no more immaculate pleasure of enthusiastic friends than a journey together into the mysterious borderline world between mind and nature. Obviously, Hulle felt the same way, and their afternoon conversations became a cherished institution that let Hulle miss many teas at the Club. Menda felt closer to him than to anybody she had ever met, and often their conversation drifted towards more personal matters without either of them feeling anxious to change the subject.

"I suppose, you might as well be the first to know." Hulle said one afternoon, when they had exhausted their debate about an experiment. "We won't be able to discuss my project for a month. But it is for a happy reason. I will be away for a while, because I am getting married, and we will spend our honeymoon on the Sarka-Islands."

He did not feel her breathless terror, and continued eagerly.

"I am looking so much forward to introducing my bride to you. She wants to meet you, and I know you would like each other. She is so much like you."

Menda was staring out the window onto Bekkel-Square. She could see the little stone wall at the far northern corner, where she had sat on the morning of her discovery of the periodic system. It was hers forever. She would never be able to share it. She had to get used to it.

The beautiful shapes

No doubt, something was weird! Either the preparation of zalat was impure, or the Menda-apparatus was malfunctioning. For the third time in a row the pressure almost doubled, as if several elements were in the plasma-state chamber. Ridiculous! As an element, zalat should read unit pressure. Why can't this stupid chamber take 6000 degrees combined with a jolt of electricity? It should not produce turmoil and wild readings at the gauge! A 1000 Amp arc should not demolish it, unless the damned machinist had taken another one of his shortcuts on the lathe.

Hulle sat down and buried his head in his hands. The hell with this machine! He had to get the data out before Orob did, and now this! Orob would bury him. And that was not the worst. His application for the summer research quarter would miss the deadline, and that would be the end of his hopes for a promotion this year. Damn it!

He could not easily ask Menda for help. Ever since he had been promoted before her, he had avoided her. Was it his fault that she had alienated several members of the faculty with her pentomino-theory? Of course, Kapp and Zerke voted against her, when she was up for promotion. This silly theory of hers had messed up everything. Why was she not satisfied with her discovery of two elements? Such an accomplishment would have been more than enough to secure the rest of her academic career. Played right, she could have used her cards for an easy Chair at the Londov University. Instead, she had to come up with this foolish concept, that every atom was, in fact, composed of five identical units. He, Hulle had performed acts of tight-rope walking in order to keep his reputation separate from hers, although he did not feel good about it. After all, he owed much to her. On the other hand, a man in his position had to consider the reputation of the College and his responsibilities for the students.

He felt that is was time, anyway, to separate his life and work from hers altogether. Frankly, she was stupid. She was still running around in the same old clothes of years ago, while Call had the nerve to patent Menda's apparatus with a slight modification for purity tests of synthetic compounds. He made loads of money with it while Menda remained an Assistant Professor with a ridiculously low salary. If she did not care about money, why should he go empty as well? He, Hulle, more than Call deserved some royalties. His hundreds of published tests and not Call's work had gained the industry's confidence in the method. If anyone... Well, Menda was a fool. The hell with her, too.

Nevertheless, she knew the machine better than anyone else. After all, she had invented it. Clearly, he had to consult her. He sighed and went over to her office.

The pentomino-theory that had upset Hulle, had angered quite a few other people, as well. They felt, that it was entirely based on assumptions and speculations. Admittedly, Bekkel had done a similar thing with his atom-theory, and had succeeded to bridge a gap of knowledge with a bold assumption. Yet, this was different. Bekkel was a genius. This Assistant Professor by the name of Menda was not. She was only a follower, wasn't she? Without Bekkel, there would not have been any elements to discover, right? Besides, at her age, Bekkel had already led an active research group. He had not been a loner like Menda.

All Menda had really done was to ask the obvious question: Why are there twelve elements? What could explain that there were twelve different kinds of atoms? It was clear to her, that the number of twelve elements meant that the atoms of the elements were composites themselves. There had to be certain sub-atoms, that associated with each other by some fundamental law in a way, that precisely twelve different kinds of atoms resulted. What law, what sub-atoms?

Nobody can reconstruct the exact thoughts that led Menda to the formulation of the pentomino-theory. The commonly accepted version of her reasoning was the following.

1. There should be 1, 2, 3,... but no more than 12 kinds of sub-atoms that combined with each other to form the twelve atoms.

2. There should be logical rules for the combinations between sub-atoms within the naturally occurring atoms.

3. Nature did things the simplest possible way.

Based on these assumption, Menda tried various models, ranging from eleven sub-atoms that formed pairs, to two sub-atoms that combined in the form of quadruplets. Each model required several quite arbitrary rules to distinguish legitimate combinations from illegitimate ones. Menda went through severe depressions as it became increasingly clear to her, that she was failing. The models seemed contrived and fabricated, but not images of a fundamental truth of nature.

Perrof's announcement of his successful isolation of a thirteenth(!) element sent a dagger through her heart. Her worst fear had come true. She could not sleep or speak for days. Of course, eventually he had to retract the claim. But during this time of deepest depression, she came to her senses. She realized, how obsessed, how personally involved she was, and that she had to stop.

Rescue came in the silence of trees. She had run to the woods. Near the creek that flowed toward the campus the tension broke. She cried. It was her despair about human blindness; it was the recognition of imprisonment, it was rejection by the Gods themselves.

When her sobs subsided, it was there. The answer was in her mind. In the following weeks she worked out the theory calmly and with great joy. There were not two, three or eleven different kinds of sub-atoms! Nature's simplicity demanded that there was only one kind, which had the simplest possible shape of a sphere or a cube. Since spheres stick poorly to each other, she decided to assume little cubes as sub-atoms: Nature's bricks were dice, why not? God had rolled dice when the world was born. She liked the thought. The cubes were packed into different groups according to certain rules. It was clear too her, that there could not be complex rules which excluded some groups and permitted others. Nature never really excluded anything. Nature was constructive, assertive. That was the obvious truth of the creek. Menda tried various schemes of grouping cubes, yet this time she was relaxed and confident. Soon it all fell in place:

Disregarding rotation and reflections there are exactly twelve different ways to pack cubes into groups of five, provided the groups remained flat. Twelve were ALL possible shapes. None were excluded.

Bekkel had been right. All atoms were made from the same material, but differed only by their shape. He had failed to predict, though, how beautiful they were (Figure 1).

Ascent in the ice

The memory of her discovery of the pentomino shapes of atoms flashed before Menda's mind, now that she faced the audience of her promotion seminar.

"Before I go any further, let me introduce a set of very interesting shapes, that are called 'pentominoes'. There are exactly twelve of them. I put them on the blackboard here."

She opened one of the wings of the blackboard that revealed a drawing of the twelve pentominoes.

"Tonight I should like to present to you the hypothesis, that the shapes of the twelve atoms resemble the shapes of the twelve pentominoes."

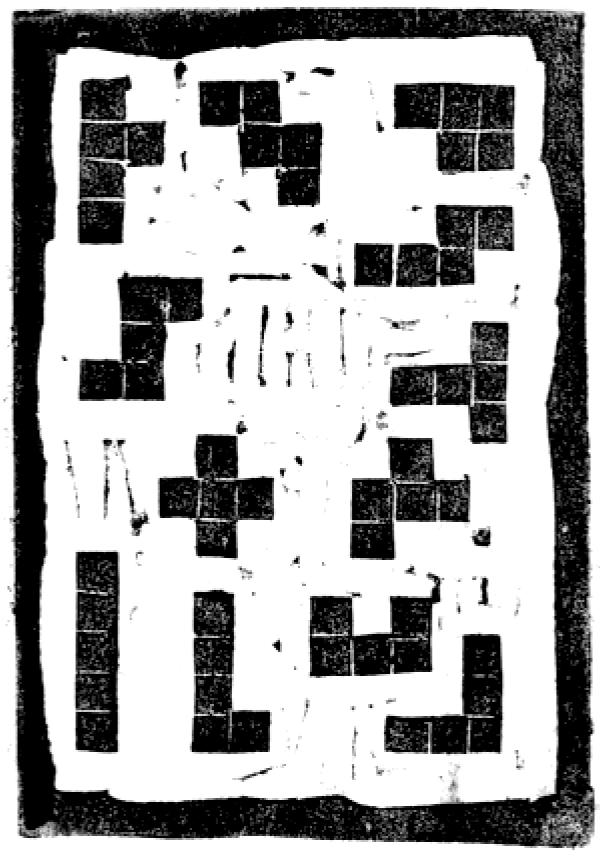


Figure 1 The twelve pentomino shapes (= twelve plane figures formed from 5 touching squares), which resemble the shape of the atoms of the twelve elements out of which planet Gabo is built.

She had spoken the last words with strong emphasis. Then she continued in her normal voice.

"The hypothesis is in agreement with Bekkel's shape-theory of the elements of many years ago."

She began to warm up. Her voice grew stronger. She had saved this next point for today's lecture, and therefore was able to add spontaneity to her enthusiasm. She felt strongly, that her explanation of the periodic system of elements based on pentomino shapes had to convince everybody by its inherent clarity.

"The hypothesis also offers an explanation for the periodic system of elements. As you know, it is actually a periodic system of the elements in their diatomic form. Based on Bekel's idea that the properties of matter are ultimately dictated by atomic and molecular shapes, one may expect that the diatomic molecules of the elements within the same group also have the same shapes."

"Let us now look at pentomino pairs instead of diatomic elements. Take two copies of pentominoes that look like the letters N, Y, and I, and pair them with themselves like this."

She drew it on the blackboard. (Figure 2)

"Obviously identical compound shapes arise. The same can be done with the pentominoes that resemble the letters T, V, and L. They too have identical pair shapes.

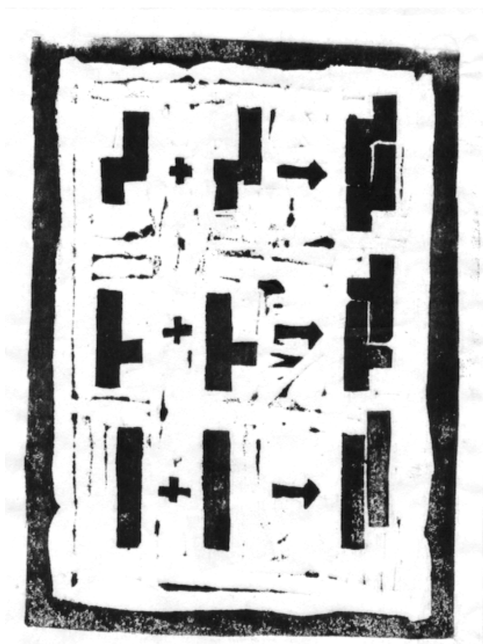


Figure 2 The N-, Y- and I-shaped pentominoes can be paired in such a way that the same shape results. Menda used this property of pentominoes to argue that the atoms are pentomino shaped.

Now look at pentominoes with the shapes similar to the letters W, U, and P. The same here! In other words, there is a remarkable parallel between the twelve elements that form four groups of three diatomic molecules on one hand, and the twelve pentominoes that also form four groups of three identical pairs. In the fourth group both, not only the elements but also the pentominoes make an exception. I shall talk about it in a minute. But first let me write this down."

She drew the paired pentomino shapes on the blackboard, already in the arrangement of the periodic system. Each of the three identical double-shapes formed a row. She admitted that she could not yet assign the names of elements to the various shapes, but added that at least one element could be tentatively assigned a pentomino shape, namely exat by the following argument.

"Let me now turn to the last group. obviously, two Z-, and F-like pentominoes yield identical shapes, thus suggesting that they belong to the same group. However, two of the last one namely the X-shaped one, produces a pair shape, that is different from all others, although quite similar to that of Z and F (Figure 3). Therefore, one may expect, that its properties are slightly different from all the others.

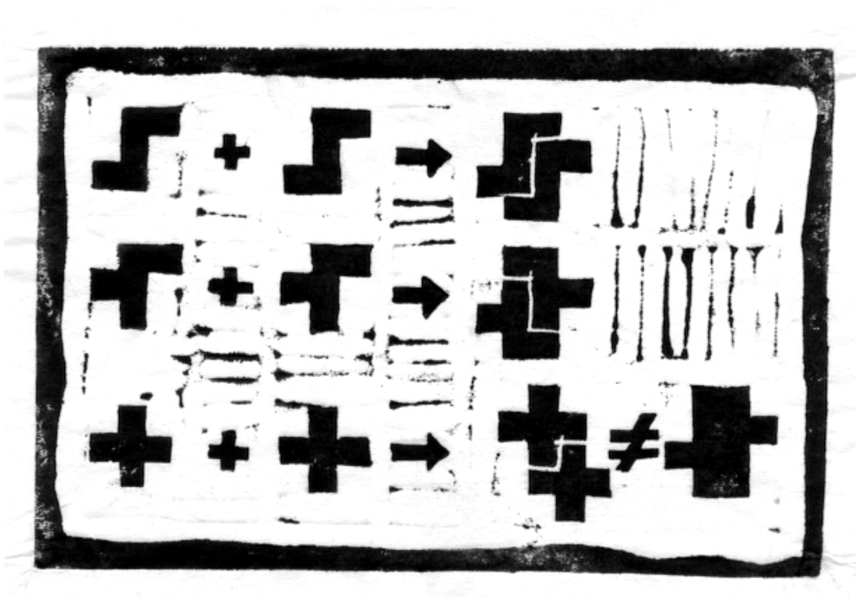


Figure 3 The Z- and the F-shaped pentomino form pairs of the sane shape, but not the X-shaped one. Based on this special property of the X-pentomino, Menda argued that the atoms of the element exat resemble the X-pentomino.

Considering now the real elements, let us compare exat with the other elements. It belongs to group IV, because it shares most of its diatomic properties with zalat and starat, yet it does not co-purify with them or any element of the other groups. In other words, exat behaves within the periodic system of the elements as the X-shaped pentomino among the other pentominoes. Therefore, I suggest that the atomic shape of exat is that of the X-pentomino."

This moment was supposed to be the climax of the lecture. Bekkel's search for the elements, his loosing battle for the acceptance of his shape theory of atoms, the old man's eyes at their encounter, the warm sunlight on Bekkel-Square when Menda had discovered the periodic system, the moment of insight at the creek! All this merged and swirled and gave birth to the star-shaped atom of exat!

"Excuse me" said a woman in the front row. "It seems to me that... Well, by pairing pentominoes one can form many other shapes than the ones you have drawn here. Off hand, I would say that there are at least six additional ways in which the W-shaped pentomino can form pairs."

Yes, she was right. Of course, she was right. Menda began to explain, that the shapes she had chosen had special properties. In the first place, they were symmetrical, and furthermore, they had maximal contact area between the two pentominoes. Besides, only this set of shapes generated four groups of three. Again, she reminded the audience that it was the simplest way of generating Nature's diversity. There was no simpler way to generate exactly twelve different shapes...

She convinced nobody, and deserved it, because at this moment she was blind. Strange, how there could be blindness in the midst of the visionary clarity of the pentomino concept. What she had said was true, it was ingeniously true and beautiful (Figure 4), yet she could not respond to an obvious objection.

History shows us many barriers of people, decades and centuries that in retrospect seemed easy to take. Yet people stopped there and turned back. It was THEIR barrier. This one was Menda's. Many years later, Haneck would not only overcome this barrier with ease, but use it to strengthen the pentomino concept. Precisely the multiplicity of pair shapes would become the basis to complete what Menda had started tonight with exat, namely to assign unambiguously a pentomino shape to each element.

At the moment, however, she offered little more than a set of mathematical shapes arranged into four groups of three, with a tentative assignment of one shape to the element exat. There was nothing to test. No proof, no basis for others to re-evaluate their own data, no clear take-home lesson supported her claim. Menda's intended climax had vanished.

When she had finished the lecture, Bok asked for questions from the audience. There were none, and people quickly left the room.

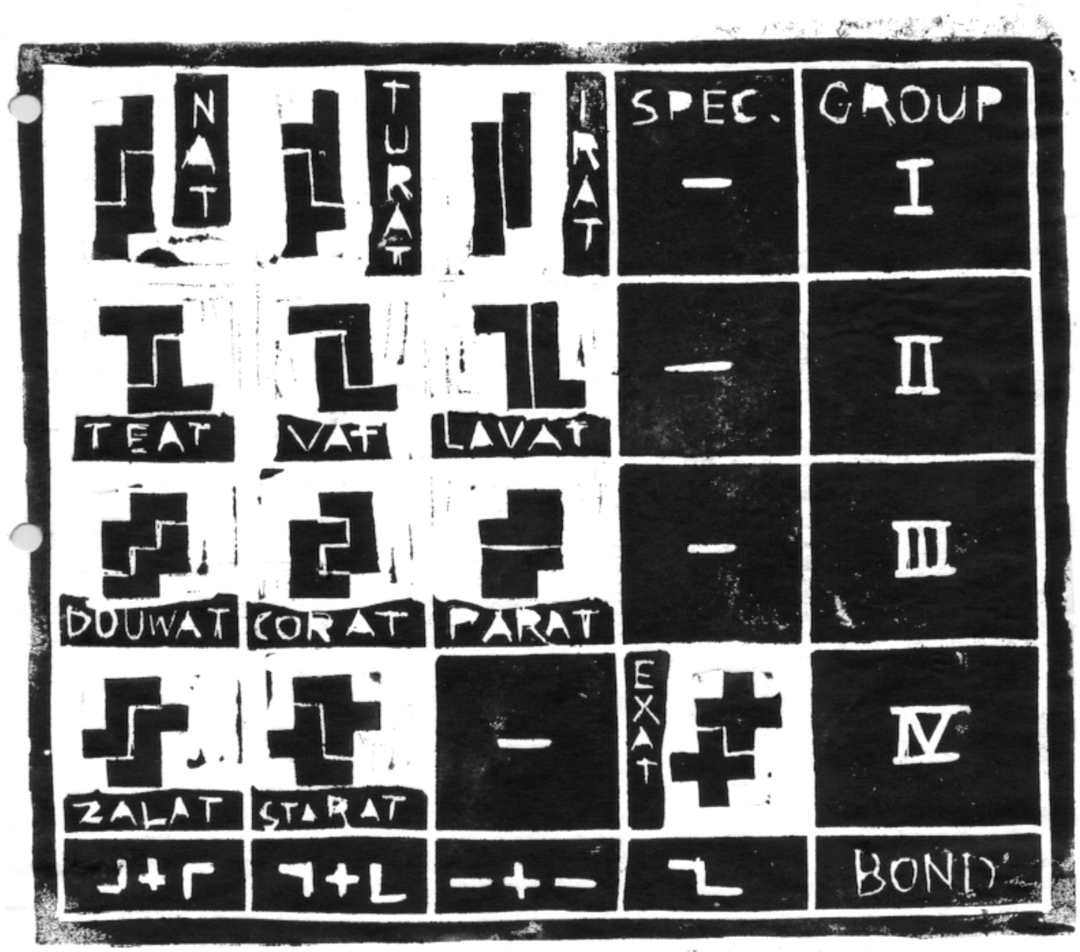


Figure 4 The periodic system of the diatomic molecules of the twelve elements on planet Gabo, showing the identical shapes of the paired pentomino shaped atoms in each case. The elements nat, turat and irat form the same diatomic shapes, as do teat, vat, lavat and douwat, corat, parat respectively. In this way the three groups I, II, III of the periodic system form. The last group containing zalat and starat contains a special shape formed by exat. The bottom line shows the common type of division line (= bond) between the two atoms of the elements in each column.

The soothing hands

In the weeks following her disastrous seminar, people showed their opinions of Menda more openly than before. There were those who saw wisdom in tip-toeing around the powerful. After Menda's fame had risen, they were eager to include her in the loops of their cautious dances. Now they felt compelled to express her exclusion from their loops.

There were those who taught the wisdom of the rules of the pack: Don't ever be different, or else the pack will cannibalize you in time of need. How urgent to let Menda know!

There were the more quiet ones, who believed that this world was the world of people who opened a laundry at a street corner, and over the years came to own the entire block, then founded a chain of laundries, and continued their lives preventing others from opening their own laundries. These people felt sorry for Menda's inabilities to run a laundry.

There was condescension among the older professors who could prove to themselves that the steepness of one's ascent did not relate to the height of one's success. There was also sincere sadness among some students who had been encouraged, and as it seemed now, let down by Menda's example.

In Bok's honor it must be said that his behavior had not changed, whereas Hulle had visibly moved away from her. He remained polite, but was likely to ignore a note that she left on his desk. No longer did he bring his visitors to her, or join a group of people who were listening to her. At earlier times he used to orient his questions after a seminar along hers, whereas now he preferred to follow a question of hers with an unrelated one, as if hers had been irrelevant. At two occasions, he had interrupted her and questioned indirectly her competence in a technical matter.

Therefore, she was quite surprised at his request for advice, and listened with reservation to his story of the tumultuous pressure increase at 6000 degrees upon an electrical discharge.

"It reads reproducibly 1.7 times the pressure at lower temperatures. Could you imagine what went wrong? Is the gauge not working at higher temperatures?"

Menda' s surprise at the turn-around of his behavior quickly gave room to a turbulent mixture of emotions. It could not be what she thought it meant! Reality does not give presents like this, or does it? Surely, some cruel demon was moving in for the final kill, hoping that she would take the bait. Or could it be a prank of Hulle's? Was he capable of playing a joke on a drowning person? Cautiously, she asked the necessary questions.

"The pressure goes back to normal, when you cool the apparatus?"

"Yes," answered Hulle." You can go back and forth several times."

"Have you tried any other element?"

"No. Do you think the pressure depends on the material? I can go back and do it right away."

Menda nodded quietly. He sounded genuinely disturbed, and obviously he did not suspect the explanation that was beginning to fill her mind with a sound like fanfares.

"Is it a sharply defined temperature? Does the pressure creep up in some way?", she asked.

"No, " he said. "It's like some zalat was all of a sudden added to the chamber. In fact, that's what I am wondering about. Is there a possibility, that some material remained absorbed to the walls, or some other place, and was suddenly released at this temperature?"

No, there was no possibility. Menda was sure of that. The injection port had no space where material could hide. The material of the chamber wall had been chosen carefully to be non-adsorbent.

"Could you see any change of color above the critical conditions?" she asked.

"Yes," he answered surprised. How did she know? That was another point of confusion. The red plasma of zalat had turned pale, as if it was thinning out, or as if the machine was loosing material. Yet, when he cooled down the chamber, he seemed to get it all back including the color.

"I want to see that." she said quietly. Her suspicion had turned into conviction. Intellectually, she knew that the impossible had happened. Emotionally, she did not yet dare to accept it.

"What do you think it is?" asked Hulle while they were walking over to his laboratory.

"Fragmentation of atoms." she answered quietly.

Hulle stared at her as if he saw a ghost.

The fall of his protege had saddened Bok very much. Only a month before her embarrassing seminar, he and the faculty had discussed details of an offer that would keep Menda at the College. After her discovery of the twelfth element and the formulation of the periodic system of elements, other universities made her attractive offers. Fortunately, she paid little attention to worldly honors, and rejected the offers politely. In fact, she seemed completely absorbed in a new problem, and Bok like many others had been waiting for another splendid breakthrough.

What a disaster! Why in the world did she have to come up with this silly theory? It was a disappointment for everybody. Five cubes! My God, what had happened to her? There was no proof of anything in this whole speculation. No proof for "five"; no proof for "cubes"; no proof that there were only twelve elements! He and others had tried to prevent the ruin of her reputation. In vain! She continued to tell everybody about pentominoes. Bok remembered Zerk's icy tone after she talked to him. Of course, he objected to her promotion. So did Kapp. With these two influential votes against her, Bok was lucky to prevent her dismissal from the staff.

In view of the past developments, it was quite confusing for him to see Hulle and Menda in front of him as if nothing had ever happened. Both were burning with desire to share their latest discovery.

"... so we set out to isolate the putative impurity." continued Hulle. "You can see the details of the method in the paper. In principle, we used high temperature resorption to separate the two. We got three fractions. One stable fraction, namely the original zalat with an atomic weight of 1.0. About 35 percent. The other 65 percent consisted of two fractions of equal amounts. Totally new substances! One had an atomic weight of about 0.8, the other of about 0.2."

Hulle paused, to let the significance sink in. Bok thought for a while, nodding his head and wrinkling his forehead.

"Point-two." he said.

"Point-two", repeated Menda. "Actually, 0.22 plus or minus 0.03, to be exact."

My God, she was right! At the critical temperature of 6000 degrees the alleged smallest units of matter, the atoms, fell apart! And one of the fragments was exactly one-fifth, just as she had predicted.

"Are there any other elements that work like this?", he asked. "Yes," Hulle answered eagerly. "So far, we found the same results with lavat, exat, irat and teat. For some reason, it doesn't work with starat and douwat. But we are still trying."

Of course, Bok submitted their paper to the Reports of the National Academy of Science. It was a sensation like none before. The sub-atoms existed. Menda was right. Based on Hulle's discovery of the critical temperature she had shown that the cubes were one-fifth of the atomic weight. Only a fool could escape her conclusion that atoms were pentominoes, i.e. made of five cubes.

Yet, doubts persisted. Why did douwat not decompose in a similar way as the others, and why not parat? Then there was the problem of the exact value of the atomic weight. It should have been exactly 1/5 = 0.20, but invariably turned out to be somewhat larger, 0.21, 0.25 or so. Why? Consequently, the larger fragment was not exactly 0.8, but was smaller, more like 0.75 or so. Of course, there is always room for experimental error, but why did the larger numbers come up consistently? Most disturbing, however, was the one-to-one ratio of the fragments. If Menda was right, there should be other fragments, too. In addition to the 1/5th and 4/5th fractions, that Hulle had discovered, one should find 2/5th and 3/5th fragments, too. Why did they not exist?

All objections were dismissed. In view of the success of the pentomino-theory, such doubters were regarded as defeatists. Of course, there would be an explanation eventually! After all, we did not yet know the forces that held the cubes together. Once, they were known, the answers would not be far away. The wrong details would come out in the wash.

A few decades later, indeed, they did. The atoms of each element are shaped like pentominoes, but the one-fifth fragment, whose discovery had set the future development of science in motion, was not a cube. Its weight was 0.2222... and not 0.20. There were no subatomic cubes.

CALCULUS OF THE MASTERS
The flame of pride

Gennar was convinced that the Gods resembled spheres, the most perfect of all bodies. Unfortunately, it was difficult to define the word 'resemble' with respect to Gods. To human eyes it could mean the appearance of three-dimensional objects. But, of course, the Gods had to be multi-dimensional. Otherwise, any four - or higher-dimensional demon could play havoc with them. Imagine the Gods chasing after one who jumped dimensions, leaving them helplessly behind every time! Clearly, Gennar could not reconcile three-dimensionality of the Gods with the requirement of their dignity.

Yet, if the Gods were multi-dimensional, the mere three dimensions of our human world made it in their eyes an infinitely thin film, a shadow, a canvas to paint on. How could they have come to us shadows in order to teach love and eternity?

All this was heresy. Elisa, the Mother Superior of the Order of the Sacred Crescent, was quite aware of her novice's aberrations. On the other hand, Sister Gennar was an exceptionally lively teacher and a true asset for the Order.

She had been a prodigy in mathematics. At the early age of twelve she had received her degree in mathematics from Ro'alam University. Despite the misgivings of older faculty who could not imagine a twelve year old professor teaching twenty year old students, Gennar had been offered a position in the department. Yet, she had declined. She wished to study theology, her second obsession besides mathematics.

Mother Elisa had never seen any relationship between mathematics and ungodly ways, and she accepted Gennar to the Order. Unfortunately, she did not know exactly how to guide Gennar's soul. How can you guide someone who keeps escaping into regions you cannot enter? For the time being, Gennar was permitted to follow her inner voices.

Nevertheless, Gennar's latest interest in pentominoes was going a bit too far. She had heard Menda's historical lecture on the shape of the elements, and had been instantly convinced. Of course, the Gods would play mathematical games! Of course, they had created infinite diversity from simplicity!

As a mathematician, Gennar knew very well that one needed only two elements, zero and one, to create infinite diversity. Why had the Gods chosen twelve elements? It was colorful, artistic, playful, creative, though. Yet, in a sense they had created the infinite diversity of the world out of two elements, nevertheless. They had used the sub-cube and the void, the one and the zero of their binary system. It was obvious to Gennar, that one had to group sub-cubes into sets of five in order to create exactly twelve elements. Why had Menda spent so much emphasis on a trivial point? Anyway, Gennar was delighted that the Gods were playing games of mathematics.

Unfortunately, this way of reasoning was neither obvious nor acceptable to Mother Elisa. She did not believe that a nun was supposed to make guesses about the motivation of Gods. This was pride. It seemed good advice, to occupy Gennar's mind with a little more physical work. Thus, she was placed in charge of the Order's gardens.

The messy wards.

Gennar was not particularly fond of plants, but she approached her assignment responsibly. She was grateful that Mother Elisa had not assigned her to the much larger fields of the Order. She lacked experience in farming, and her body was not built for the strain of ploughing, sowing and harvesting.

Even the gardens seemed too large at first. There was a pond, a large grove of linden trees, the lawn with many flowering bushes, an acre of flowers and fruit trees, gravel walks, stone benches and a moss covered fountain. A wall of field stones, covered with moss and ivy, and twice the height of a person enclosed the garden like the walls of a church. It was always quiet there, even birds seemed to lower their voices.

Day by day Gennar worked in the gardens. Rain or storm, heat or early snow, she tilled, weeded, irrigated, fertilized, raked, cut, pruned, fought vines and picked snails and insects off the leaves. Day after day she learned more about the art of gardening. At night she was too tired to study her beloved mathematics and fell into a death-like sleep until sunrise of the next day.

She was still longing for the pleasure of exploring the crystalline worlds of premises and theorems. Yet, she was surprised to discover that she did not miss it any more than she did. Working with soil and plants, feeling wind and sun, watching the sun's orbit and knowing the seasons provided a new fascination for her.

Mother Elisa was pleased to see Gennar's education take the intended ways. When time permitted she joined Gennar in the evening before the prayer bells sounded. Then they sat silently and dreamed into the ever darkening depth of the gardens while its century old memories awakened.

As fall approached, Gennar was surprised that she was worried about her plants and asked the Sister Carpenter to build little shells to cover the delicate bushes and the trunks of the old cherry trees. She covered each flower bed with layers of leaves and weeds, and felt peace when all the entrusted lives were secured. Nothing could be done about the huge, old linden trees in the grove, though. They had to take care of themselves. Nevertheless, Gennar spent many hours near them wondering whether she had neglected any of her duties.

Life around her was nostalgic. There was satisfaction over a summer well lived. Happy sadness heralded the end of all things. Knowledge of future springs and fatigue from life's exhaustive gifts made every life feel like a mother who had bedded her children, after a long day's work.

Gennar no longer felt that she had neglected mathematics. Winter was the appropriate time for it. The crystals of ice, the rules of rigid clarity, that was mathematics. It was Winter itself. There was a time for everything. Oh, how happy she was to have found her time for logic.

The other part of the year belonged to life, to the bustling chaos of all creatures bumping into consequences before heeding any causes. Summer was anti-mathematical, it was anarchy. Maybe, her plants were a little more dignified than butterflies and sparrows, but chaotic, nevertheless. Yet, they seemed to take it all in good humor. If mathematics was not their thing, they were wonderful and courageous for the very act of living.

The chains of love

Whenever she saw the old linden trees, it seemed that wind and rain from past centuries awoke and whispered to her. The Founding Mother, Clare had planted them with her own hands. This was long, long ago. Age had left scars all over them. In weird, asymmetrical gestures the gnarled branches reached into the sky.

'You don't need my care, do you?' thought Gennar and looked at the old trees. The trees, of course, remained silent. Only a gust of shivery air rose, impatient to wait for the winter.

When winter came Gennar returned for a few months to the clarity of integers. Yet, doubt had entered her mind about the value of a truth that can be proven. Doubts began to destroy her pleasure with mathematics. She caught herself looking forward to Spring and to her return to the gardens. Then one winter evening she suddenly realized that she was no longer serving mathematics. Instead, she was in the service of plants!

That's what plants were! Our masters! We needed them, they did not need us. They kept us in their service. We and other animals were to fertilize them, to couple them, to defend them against hostile animals and blights. The plants could not move their bodies to other places. So they employed humans for the luxury of locomotion. After all, we owed them our lives! Thus, we planted them, took care of their soil, defended them against pests that COULD move their bodies, and supported them after storms and frost. They lured us into harvesting their seeds and sow them out far away. They molded our minds until we disliked wilderness. They drugged us with pleasure over a well-kept and healthy garden. Together with ants, bees and butterflies, we were their slaves!

Gennar realized who had destroyed her faith in mathematics. They had done it. The ruthless, anti-mathematical anarchists with their creeping shoots and their knobby branches. They had no use for servants who believed in the crystalline clarity of logic and order. Instead, they wanted us to plough, to handle dung and to pluck insects off their leaves.

Their ugly work was done. She would never again be able to feel the pure pleasure. Her future would be spent by spreading fertilizer and tilling hardened soil. Fatigued in the evening she would be grateful for a moment of rest granted by her unsightly masters, the parasitic providers, the murderers of souls!

Mother Elisa recognized the crisis, and as winter deepened, so did the darkness about Gennar. She seemed in need of prayer. Mother Elisa bowed her head next to Gennar's. She prayed that Gennar may be spared the punishment for her lonely pride.

With the flowers wilted and gone, the original geometrical design of the garden emerged through different coloration of the soil. Gennar could recognize the earlier isosceles triangles, diamonds, spirals and circles underneath the layers of dry leaves and snow.

What a perfect idea for rebellion! If she was condemned to serve the anarchic tyrants, she could make them serve the rules of mathematics in turn. After all, they could not walk away from the patterns, could they?

Mother Elisa had no objection to the restoration of the original design of the gardens, and so Gennar made plans to submit the tyrants to a humiliating service. She would plant them in geometric patterns, and prune hedges and trees in symmetrical shapes. How ridiculous the tyrants would look! By turning gardening into a service of mathematics, Gennar thought that she had outwitted them.

What folly! When Spring came, the 'tyrants' called their 'slaves' back into service in the ancient and gentle ways that left no room for rebellion: They opened their blossoms. And rebellious novices and wise Mothers alike stood in wonder and pledged allegiance with tears of joy in their eyes.

The growth of faith

After Gennar had finally found the courage to confess her heresy to Mother Elisa, the decision was brief and firm. No further word about restoring the garden's original designs! No good could come from revenge against any creatures of the Gods.

With spring upon her, Gennar returned to the garden with renewed strength. A fading memory of the dark moments remained, but the garden flourished under her hands, and perspective returned to her mind. Soon she discovered that there was mathematics even to the spreading of faith.

Obviously, everybody in the past had been able to convert more than one heathen, or else the Faith would never have spread. But how does the number of believers grow if every believer converted just two others in a life-time?

Assume that 30 years after the Founding Mother started her mission, she had won her first true convert. Sixty years later, she had her second, while her first convert had won her first. That made 1 at the beginning, 1 after 30 years, 2 after 60 years. Then the Founding Mother died, but her two converts went on. Gennar scribbled more (Fig. 5). After 90 years there were 3, after 120 years 5, then 8, then 13, then 21,... Strange, wasn't it? The number of new believers was the sum of the preceding two. Gennar continued the series of integers:... 21, 34, 55, 89, 144, 233, 377, 610, 987. After twenty intervals of 30 years there were 6765 new believers. After thirty intervals the number rose to 832,040.

Historically speaking, that was not exactly how the following of the Faith had increased. Yet, Gennar's interest was caught and she began to play with the numbers of the series. Soon she found that every third number was divisible by 2, every fourth by 3, every fifth by 5, every sixth by 8... Here they were again! The same numbers 2, 3, 5, 8... Incredible! Another exciting thing: Take any one of these numbers, say 89. Its square is 89 x 89 = 7921. Now multiply the numbers that are adjacent to the left and right of 89, namely 55 and 144. That gave 7920, one less than the square of 89. She tried it with others. Take 55. Its square is 55 x 55 = 3025. Left and right of 55 are 34 and 89. Lo and behold, 34 x 89 = 3026. They always differed by 1. What a wonderful toy this series of integers was! Ideal for an addicted mathematician.

A few days later Gennar discovered that the series was related to the golden ratio. If one took the golden ratio to the 3rd, 4th, 5th... power, divided the result by the square root of 5, and rounded the result to the nearest integer, then one obtained the 3rd, 4th, 5th... number in the series.

Most of the starflowers were ripe. The kernels started to fall out, leaving behind a honey-comb grid in the flower head. Better than before one could see the spiraling arrangement of the kernels. Two sets of spirals resulted, one clockwise and one counterclockwise. Strange, that they should form spirals, thought Gennar, but it satisfied her to see how mathematics crept into everything.

She thought again about the golden ratio. The length and width of each kernel was related by this ratio as far as one could measure. It looked natural, harmonious. Still, she could not understand what relationship existed between the ratio and the integer series. 'My friends,' she addressed the starflowers in her mind, 'if you were mathematicians who knew the relationship between the golden ratio and the series of integers, you would not just grow kernels shaped by the golden ratio. I think you would put 144, 233, 377, 610, 987, or some other such number of kernels into your face.'

'Well, do you have 987 kernels? ' She lifted the head of a starflower and tried to count the kernels. Soon she gave up, because the many spirals confused her eyes, and she lost track of the count. She tried again, but this time she decided to count along the spirals. There were 89 clockwise spirals. In order to obtain the number of kernels one had to multiply each by the number of kernels per spiral...

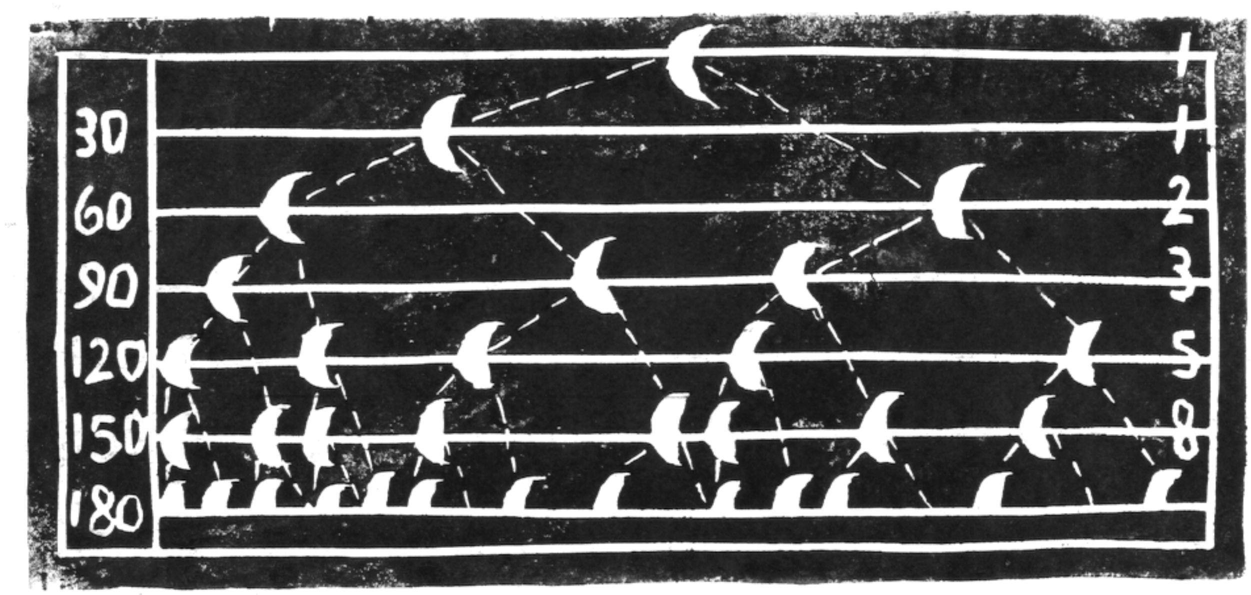


Figure 5 The sketch that led Gennar to the discovery of the Fibonacci numbers on planet Gabo. The crescents symbolize new members of the Order of the Sacred Crescent assuming that every 30 years a member of the Order wins another novice for the faith and dies after 60 years. On the left side Gennar noted the number of years passed, on the right side she counted the total number of members of the Order after that many years.

There were what?!!! She counted again. Clockwise spirals: 89. Counterclockwise spirals: 55. What?!! She ran to the next starflower. Clockwise: 55, counterclockwise: 34. These were THE numbers!! She ran from flower to flower. No exception (Fig. 6). The starflowers knew the mysterious number series as well as the golden ratio!

Her eyes widened. Spirals, there were spirals, logarithmic spirals! The leaves were attached to the stem along a helix, every quarter circle a leaf. Each leaf had a saw-tooth pattern. Those were not just saw-teeth, they were cycloids. My God! Look at the trees. One stem branches into two, branches into 4, 8, 16... Above ground the branches, below ground the roots played the same game of geometric divisions. Look at these flowers! Spheres, saddle points, parabolas, ellipses, helices all over! Hexagonal arrays in the face of this flower, spirals again in another, triangular arrangements here, pentagonal petals there! Exponential attenuation of diameter in this stem, logarithmic growth in another!

That's what they were. They were kin. The gentle tyrants were obsessed mathematicians, just like Gennar!

The calculus of mating

With renewed spirit, Gennar served the plants in the garden. She had no longer any difficulty of accepting them as her true masters. Of course, she did not neglect the service to her higher masters, the Gods. It seemed to Gennar that the Gods must love mathematics as well. They had created a universe with spinning, spherical stars and

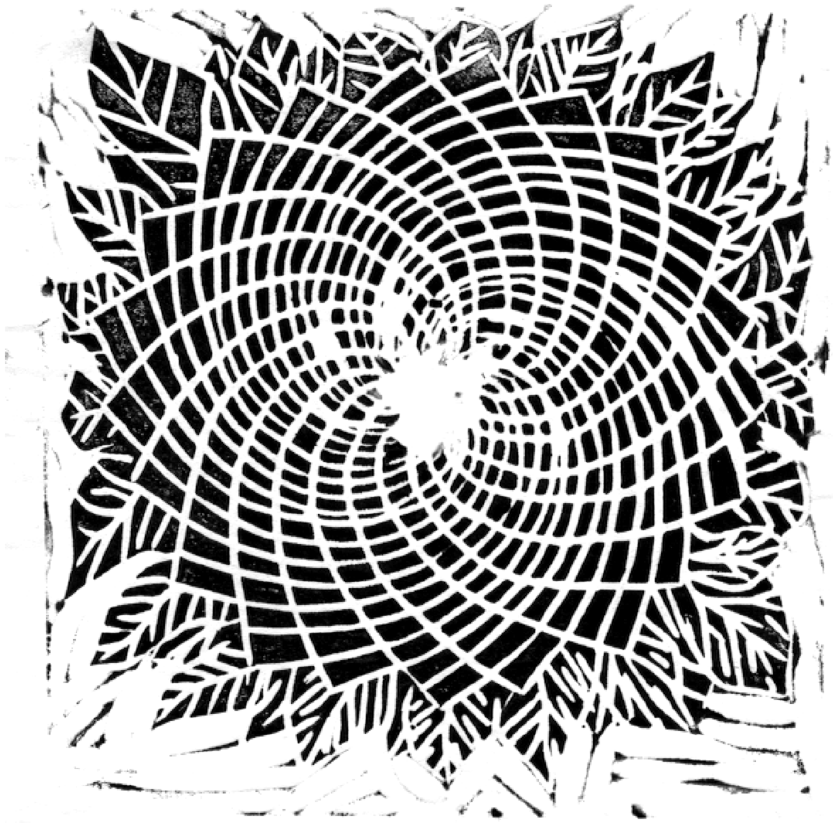


Figure 6 Typical face of a starflower with two sets of spirals. When Gennar discovers that the number of clockwise spirals and of counter-clockwise spirals are numbers from her peculiar series she begins to see that plants are obsessed mathematicians like herself. Even when they mate they play mathematical games: Gennar discovers the laws of genetics.

planets, with spiralling nebulae in the skies, with crystals in the soil and the heavens moving along circles, ellipses, parabolas and hyperbolas. All of physics had proven the mathematical structure of the universe. How else could one explain that the mathematical consequences of observed facts, were observable facts again? In a universe with the laws of dreams it would be different! Ours was clearly logical. How fitting that the Gods had sent the mathematical plants to pioneer a chaotic planet!

She realized that all the asymmetries and gnarled shapes of trees and bushes was not their chaotic work. It was the world's chaotic work. Where a plant's body deviated from rigorously mathematical designs, one could be sure to find scars left from storms, people, insects, blights, and droughts.

There were other violations of mathematical design in plants that were not scars but musical variations of a mathematical theme. For instance, Lilies turned their petals in rigorous topological deformations, forming saddle-point after saddle-point, while playfully corrugating the edges of each petal in ever more different principal curvatures of small saddle-points until the discontinuity of the very edge was achieved in a musical variation on curvature.

Or look at the flaming red and yellow patterns of dragon-tongues! At their origin the petals were purely red. Further up, sprinkles of black appeared that grew larger and less regular. Near the tip of the petals the black spots coalesced into the shape of winding black snake tongues. That was not merely mathematics but music. Surely, the masters were musicians beyond sound.

Yet, all discipline and rigor had its limit. The plants were alive after all. Gennar was convinced, that they could express irrational playfulness, not in a chaotic way but in an elegant, aristocratic way. She did not have to look far in order to find it, but only as far as her moon-flower bed.

There were blue ones and purple ones and red ones. Like the laughter of children, these colors were dancing over the flower bed. Chaos of beautiful stars with no respect for mathematics at all! Gennar loved the plants even more for disregarding their own rules in this wonderful manner.

Sister Pollus, the former gardener did not share her enthusiasm for the color variety.

"I always pull out the purple and the red ones when their buds were just about to open", she said. "In this way you can keep the flower bed purely blue. I like it this way."

Gennar did not understand.

"Wouldn't the other colors return later?" she asked "No, no", said Sister Pollus. "If there are no red ones around to pollinate, you don't get purple flowers, and of course no red ones, either."

Gennar had not really considered that the masters were breeding. Perhaps she had wanted to overlook it. How could mathematicians with their clarity do something as chaotic as mating? And if they did, the result could only be unmathematical. Yet, what had Sister Pollus said? Blue moon-flowers bred with blue moon-flowers begat blue moon-flowers. Red moon-flowers bred with red moon-flowers...

A crescent bids farewell

Play with the Masters! Play the color game! Cross a red with a purple, and the moon-flower from the seeds may be red or purple. Cross purple with purple, and the offsprings may be red, purple or blue. Cross red with blue, and they are all purple. Rules again. Rules all over. Even the Masters' mating was mathematical. It did not take Gennar long to see the rules.

Many years had passed since her first afternoon as a gardener. Word of the rules of genetics had spread. People came from far away in order to meet the famous nun, who had unravelled the secrets of inheritance of plants, which were soon found to apply to animals and humans as well.

Gennar should have been pleased. Yet, she was troubled. What she had meant and still understood as insights into the greater glory of the Gods, was increasingly taken as proof that Gods did not exist. More and more scientists tried to convince mankind that these and other laws pointed to a mechanical, automatic universe, that functioned by unfeeling laws and accidents. If there were Gods, they would rather be products of this universe and subject to its laws than its masters who could arbitrarily tamper with its events. If anything, they were prisoners of their own laws.

Gennar professed to her faith whenever the questions of origins arose. Passionately, she insisted that the universe was illogical, if it had created itself and even its creators, but people were certain that knowledge could not be wrong if it enabled them to manipulate their world.

Mother Elisa had died a few years ago. In view of Gennar's world-wide reputation, the Order had offered her to succeed Mother Elisa, but Gennar had declined, because she felt, that - though unwittingly - she had done disservice to the Faith.

Too old to work in the garden, she spent many hours with the gardeners, nevertheless. Sometimes she still searched for a moon-flower, that she had seen only once before. At the time she had not noticed how strange it was that this particular offspring of blue moon-flowers carried a yellow crescent on each petal. Later it struck her that the masters seemed to have violated their own crystalline rules. Since she never saw such flowers again she began to dismiss them as a creation of her memory. Maybe, it had never happened. The laws of inheritance were universal.

Gennar sat on the bench near the moon-flower bed. Dusk fell. She remembered Mother Elisa sitting with her on the same bench and watching the gardens darken in time of her greatest danger. There were powers beyond rules. Mother Elisa had mastered them.

When she got up her eyes fell suddenly on a slightly brighter glow in the graying blanket of dusk over the flower-bed. For the second and last time in her life, Gennar saw a blue moon-flower with yellow crescents on its petals. She felt the desire to go over, save its seeds and study its offspring, but presently she turned and slowly walked toward the darkening house.

THE AGE OF THE SETTLERS

View from a hill

After Haneck had shown the way, everybody found new di-, tri-, and tetra-atomic forms of elements. The present symposium on "Identification of Atomic Shapes" was a personal triumph. It was held in the same format and place as the now historical meeting on "Elements and their Role in Nature" in honor of Bekkel many years ago. What a distinction for him! This symposium was practically about his work alone. He was basking in the envy of peers and the awe of young scientists. Was it not a pleasure to be modest, while everybody acknowledged one's superiority? Even more satisfying, his old foe Perral, with whom he had shared the National Award, had not yet been honored in this way.

Of course, they had put up Haneck in the Royal Suite of the Castle Hotel overlooking the entire valley of Ro'alam. Of course, he had been given a special reception with celebrities of the entire Northern Province. Of course, he gave the opening speech of the Symposium.

The symposium did not start before sunset. Drinks had been served throughout the afternoon. He and other celebrated scientists had been socializing on the terrace of the Castle, surrounded by waiters and afternoon sunshine. It was exhilarating to watch the hundreds of nameless participants below and to know, that one had won the battle that they were still fighting. He was a little intoxicated and laughed too loud at times.

Presently, everybody was assembled in the lecture hall, and Haneck began his speech. He had given it many times before. In fact, everybody knew the story of his discovery by heart. But... , not under such glamorous circumstances!

"If there is any credit to be given about all this work, of course, it belongs to Bekkel and Menda.", he began.

"I wish they could see the hour of their triumph, after so many years of rejection. Unfortunately, neither is still with us."

He paused to conjure up the memory of an encounter with Menda shortly before her death.

" I have been fortunate to receive ample acknowledgement for my work on the identification of atomic shapes. Yet, the most precious reward I ever received came from Menda." He paused again.

"When I told her about my finding that rapid-cooled elements in the plasma state formed new diatomic molecules, she immediately recognized their potential to assign pentomino shapes to atomic shapes. With a quiet laughter in her eyes she said, 'What a humorous world, that turns my limits into your achievement!"

He had to collect himself, because the combination of alcohol, grandeur and nostalgia was about to block his vocal chords. After a few effective seconds he continued.

"In retrospect, it seems obvious how to continue Menda's work, but at the time there was a great deal of skepticism. Not only was it unclear whether the atoms of elements had pentomino shapes at all. In particular, there was no way of telling which pentomino shape belonged to which element."

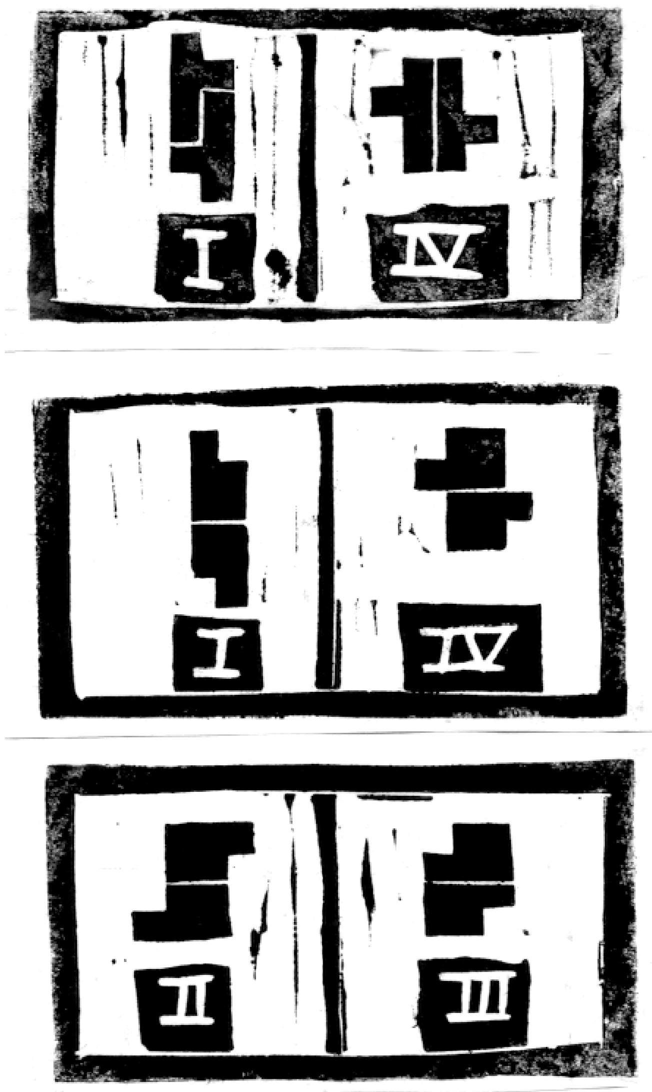


Figure 7, 8, 9 Some pentomino shapes of one group can pair to form shapes of another group. The Y-shaped pentomino (Figure 7) and the P-shaped pentomino (Figure 8) can make pair shapes that belong to groups I and IV. The P-shaped pentomino can also pair to form shapes of groups II and III. Haneck discovers that under special circumstances the elements turat and parat can form diatomic molecules that seem to belong to other groups of the periodic system. He uses this finding to identify which element has which pentomino shape.

He raised his hand as if guarding against an objection.

"I should correct myself. One element had been assigned to a pentomino shape, namely exat. Menda herself had done it. Her perfectly valid argument was based on the fact that the X-shaped pentomino generated a diatomic shape that was not matched by any other pentomino pair. At the same time, exat's property in the diatomic state were slightly different from any other. It was closest, though, to zalat and starat. Therefore, she argued that the atomic shape of exat was that of the X-shaped pentomino, and today, based on many independent experiments, we know that she was right."

He went over to the blackboard and drew all twelve pentomino shapes. Then he crossed out the X-shaped one and wrote 'exat' underneath.

"Here we have the first. What about the others? The key to their identification lay in a discovery that I made several years ago. As you all know, in the plasma state each element exists as a single atom. Menda's discovery that all elements have the same atomic weight was based on this observation. When plasma is cooled again, the elements return to their diatomic state, which was the basis of Menda's discovery of the periodic system, as you all know, of course."

He drank from a glass, because his voice had become hoarse.

"I had always been interested in the way, diatomic molecules actually formed. Did two of them simply get together, or did they exist initially in intermediary poly-atomic stages that split later into pairs?

When Linder published his famous method to generate very low temperature liquids, I decided to use it for rapid cooling of plasma. The rational was, that I might perhaps be able to freeze some of the shortlived intermediary states that would help decide in which way the diatomic elements formed. As you all know, it turned up a quite different result: The resulting rapid-cooled plasma contained many NEW diatomic forms of elements. It was easy to isolate them by the usual pressure-resorption techniques, that were pioneered by Menda and Hulle. What we found was at first very confusing, but later became the key to shape identification."

Everybody knew what was coming, although it seemed as if Haneck was telling the story for the first time. Like children listening breathlessly to their favorite fairy tale the audience sat quietly in suspense, waiting for the climax of the story that everybody wished had happened to him or herself.

Triumph of a hamster

Drawing after drawing appeared on the blackboard. Haneck showed with polished phrases which of the pentomino shaped atoms of a certain group of the periodic system did not only form pairs characteristic for their own group, but also were able to form paired shapes of another group. For example, the Y-shaped pentomino did not only form the pair shape for its own group I, but also for group IV (Figure 7 and 8). There were many other cases (Figure 9).

Most important for the identification of pentomino shapes with the atomic shapes of the elements were the cases of diatomic molecules that formed from elements but belonged to none of the groups of the periodic system. In order to demonstrate this, Haneck took a piece of chalk and wrote on the blackboard his famous chimera system of elements.

1	**IRAT**	**LAVAT**	**PARAT**
2	**ZALAT**	**LAVAT**	
3	**DOUWAT**	**LAVAT**	**STARAT**
4	**DOUWAT**	**NAT**	
5	**TEAT**	**LAVAT**	**STARAT**
6	**NAT**	**TEAT**	

"What it means," he continued, "is the following. In addition to the compounds known to Menda, we found that diatomic irat, lavat and parat formed a set of compounds which had identical properties, but were different from all others, normal or otherwise. Similarly, zalat and lavat formed such a set, and so forth. How can this help us to identify the particular pentomino shape that belongs to which element?"

Of course, everybody knew the answer, but what pleasure it was to relive this important moment of science!

"Let us leave the experiments with the atoms of real elements for the moment, and play games with pentomino shapes, instead. Which symmetrical pair shapes can we find in addition to the ones of the periodic system! Let us first look at the I-, L-, and P-pentomino. As pairs they can form a common rectangular shape (Figure 10) which is quite different from the shapes of the groups in Menda's periodic system (Figure 6). But there are more!

I have prepared them here in this drawing on the blackboard, and I must confess, that I arranged them - somewhat unfairly - already in a way that matches the chimera system."

He opened a wing of the blackboard and - like Menda so many years ago - revealed a drawing of paired pentomino shapes. It contained six groups of identical diatomic shapes, that could be made from two identical pentominoes. In that sense it was similar to Menda's periodic system. However, there was no periodicity of certain properties and they did not contain the same number of elements in each group. (Figure 11)

Figure 10 Pentominoes can form pairs that are different from any of the periodic system. For example the I-, L- and P-shaped pentominoes can pair to form a rectangle. Haneck undertakes a systematic study of these possibilities and compares them to newly discovered 'chimeric' pairs of atoms of different elements in order to complete the identification between element atoms and pentomino shapes.

"Before any misunderstandings arise, these are not the only diatomic shapes that exist. In fact, this meeting's program shows many examples of others. What you see here are selected diatomic shapes of certain elements that can be matched by certain others."

He smiled like a little boy who had been caught snatching candy.

"Actually, I am getting ahead of myself. I am not allowed to call them diatomic shapes, yet. At this moment they are merely a set of pairs of pentomino pieces that can be matched by other pentomino pairs. Whether they exist as diatomic elements is exactly what I still wish to prove to you. So, please return with me to the time when it was not known that these shapes up here are real objects of the atomic world." In pretended despair he looked up to the ceiling. "It is so difficult to force the truth into the framework of chronology. That's what I used to tell my mother when I came home late from a date."

Everybody laughed, and Haneck put on a serious expression again.

"If you compare the chimera-system with this drawing here, it is obvious how to match pentomino shapes with elements. For instance, lavat occurs in four different groups of the chimera-system, and the L-pentomino occur in four different groups of the pentomino-system here on the blackboard (Figure 11). Therefore, we can start by identifying the atomic shape of lavat with the L-pentomino. And so forth and so on."

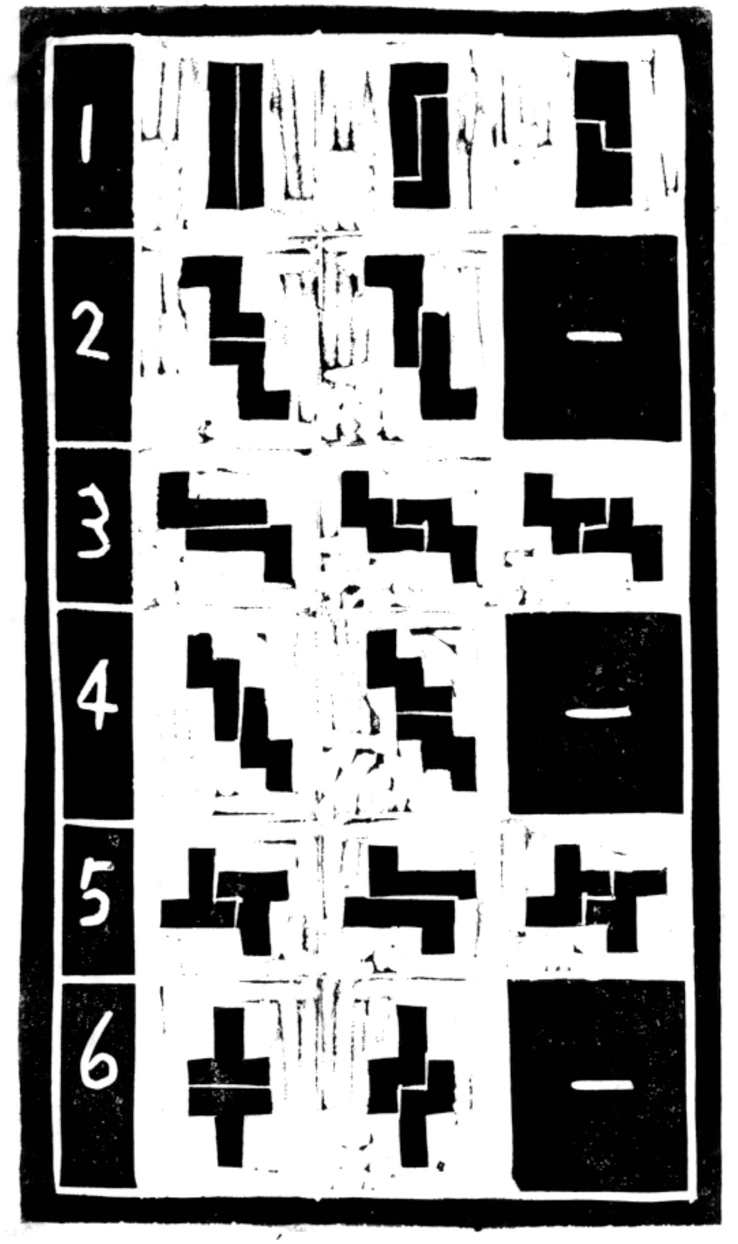


Figure 11 Haneck's complete system of chimeric pairs, that achieved the complete identification between the atoms of the twelve elements and the twelve pentomino shapes. He finally proved Menda's ingenious insight as expressed in the periodic system on Figure 6.

During the last sentences, he had spoken faster and faster. When he suddenly stopped, silence remained in the room that expressed admiration for him, but also for the esthetic beauty of science.

"If I may add a personal comment," he said after a brief pause, " I should like to say something to the young scientists in the audience." He thought for a few moments, and then continued.

"We all sacrifice much for our profession. Paradoxically, we struggle for goals that we cannot know until we reach them. We use existing knowledge to gain new insights which will ultimately destroy the basis we needed to find them in the first place. Our work is not rewarded by wealth and power. Keep in mind when you are striving for success that it is never yours. Although there are awards for individuals, success belongs to all of us. Whatever my work may be worth, its credit goes to Bekkel's and Menda's monumental battle with the blindness of their time. And if there is fruit of my work to be harvested, it is not mine, either. It is all yours."

His chemical intoxication had given room to drunkenness with his own glory. The following applause, the secret tears in the eyes of young scientists, the sunlight falling through the tall windows of the convention hall, it all swirled about him like a dream.

Crystalline power

Intermission was as usual. Neither the audience nor Haneck knew, what Osta had in store for them. The first speaker after the break, she sat alone in the lecture hall preparing her presentation, while everybody else mingled outside.

"I think his work has improved. Considering this idiotic paper on melting points, his latest experiments show at least that he has understood what science is all about."

"Why in the world did they give her the job. She hasn't done anything.."

"... besides sleeping with everybody."

"Oh, come on. You know that Pecker has spread this rumor.."

"If Haneck wasn't such an arrogant ass, it would be much easier for me to believe in pentomino shapes."

"What?! That again? You can't be serious."

"I think that Bekkel was really the greater of the two."

"Of course the main question is, what holds the atoms together. I wish everybody would stop worrying about geometry and focus a bit more on dynamics."

"This latest paper of Marek is nothing more than a rip-off of Paladin's discovery. Why the hell does everybody print her?"

"Oh, come on! If you had served on the editorial board as long as I have, you would know that it's not the quality of the journal that is lousy. It's the manuscripts that flood the office every day."

"This was a very interesting talk you gave."

"Thank you. I don't think we have met."

"Sorry to interrupt, my name is Sarfit. I am at Rocar University. What I wanted to ask you is, uh, we have done some work on refraction, too..."

"Excuse me Professor Haneck, may I ask you a question?"

"Yes. Sure."

"I hope you don't misunderstand me, I am quite convinced that atoms have pentomino shapes, but, em, uh, I am not sure how to, uh, formulate this. What is the evidence that they have this shape before we bring them into the plasma state. Could it be that, em, that matter shatters so to speak into such formed pieces, but really didn't consist of them before?"

"That is a very interesting question. The main argument for the preexistence of the atomic shapes is their reproducibility. It is difficult to come up with a mechanism that allows homogeneous matter to break into the same kinds of pieces no matter what the "shattering blow" was. But of course, there is no direct proof as yet. I think somebody should work on that. Maybe you?"

"Oh, no. I am not really in the field. But, uh, the, uh, fact that atoms can fragment into even smaller pieces above the critical temperature mean that the process of matter breaking up of... "

"I am sorry, you have to excuse me. I have to go now. But think about reproducibility."

"But couldn't reproducibility simply mean that the pieces look alike on the average over perhaps millions of fragments. We are never dealing with only one atom, but with millions, perhaps more at a time?"

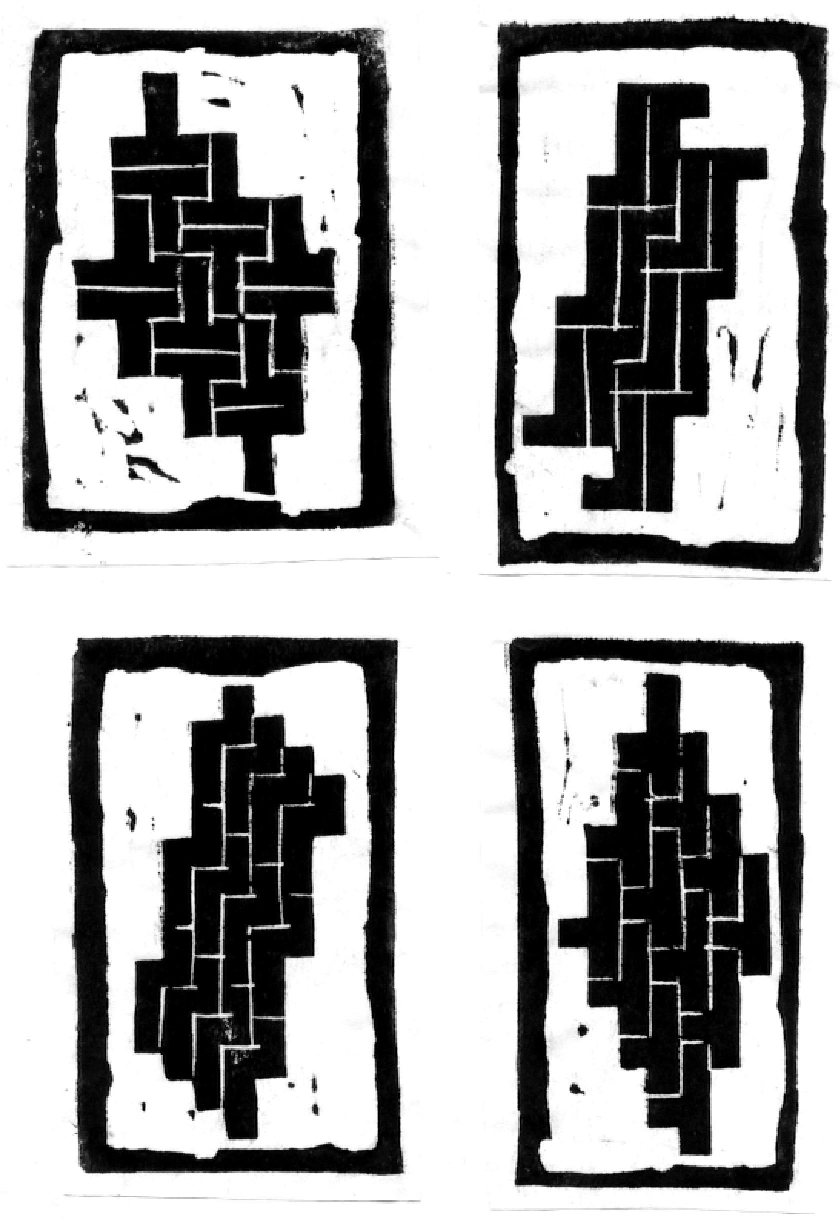
"I really have to go now, but I think that the average fragment of randomly shattered matter should look triangular and not like a pentomino. Anyway, I am sorry..."

Haneck turned away leaving behind a student who was quite angry at herself, because all her prepared arguments had vanished the very moment she had faced the great man.

Intermission was over. The first speaker after the break usually had to wait for the audience to settle down. Finally the last person had found a seat and the chairman of the session introduced Osta's scheduled presentation on the 'Fourier-transformation of elementary crystals'. It was the last time that somebody had to introduce her to an audience that had never heard of her before. During the next thirty-five minutes she succeeded in stealing the entire symposium away from Haneck, and caused one of the greater sensations in the history of science.

So far, nothing indicated that. Even the title of her talk was unintelligible for most of the participants. Consequently, hardly half of the seats were occupied.

She began with an introduction to the diffraction of light and its mathematical formulation by Fourier. Then she mentioned the more recent discovery of X-rays and the methods to record them. Her voice was clear and calm. The intelligence and discipline of her presentation increasingly captured the audience. Finally she turned to her own work.



Figures 12 Internal structures of crystals of the elements as discovered by Osta. Using X-ray diffraction these crystals she not only proved directly the pentomino shape theory, but also measured the size of the atoms and the wavelength of the X-rays.

"We were interested to see what molecules would form if plasma was not cooled rapidly, but extremely slowly. The cooling rate we applied was less than one tenth of a degree per minute. Therefore it took about three days to cool plasma to the temperature of liquid air. Afterwards we found the walls of the cooling chamber covered with a layer of shiny, thin flakes that could be collected quite easily. They ranged in size between a hundredth and a tenth of a millimeter. This drawing shows you a naturalistic view of these flakes."

She hung up the first sheet from a stack of posters.

"As you can see, the external angles of the flakes are the same for any given material. Therefore, they are actually crystals. We were able to prepare such crystals for each of the elements. The following table shows the crystal angles we obtained."

She hung up the next poster.

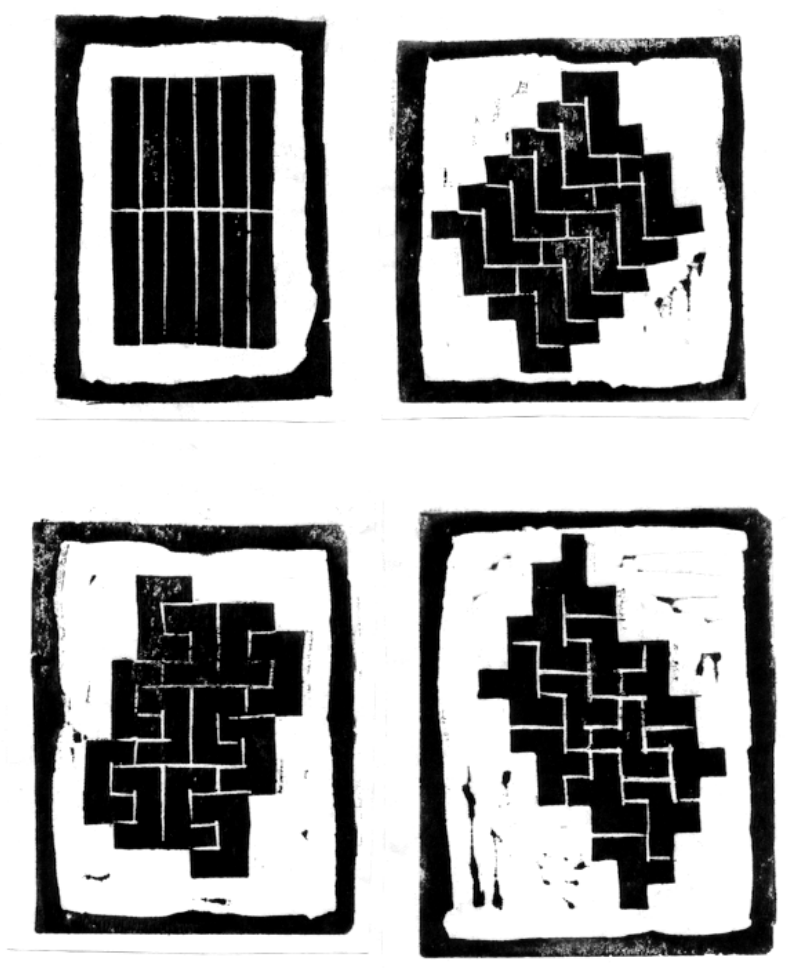


Figure 13

"For instance exat and parat have rectangular crystals. The same is true for corat, whereas vat has an angle of 77 degrees, teat has 58 degrees and so on."

By now everybody in the room had realized that an extraordinary piece of work was presented. Crystals of pure elements formed out of the gaseous state?! Some people left the room to call in their friends, and the door in the back squeaked frequently as more people came in. Soon the seats were filled and people stood in the aisles near the door. The commotion caused considerable noise and Osta had to shout several times in order to be heard.

"We subjected the crystal to X-rays and found to our surprise that they diffracted it. The next figure shows you an example of the diffraction pattern of turat."

The next poster went up.

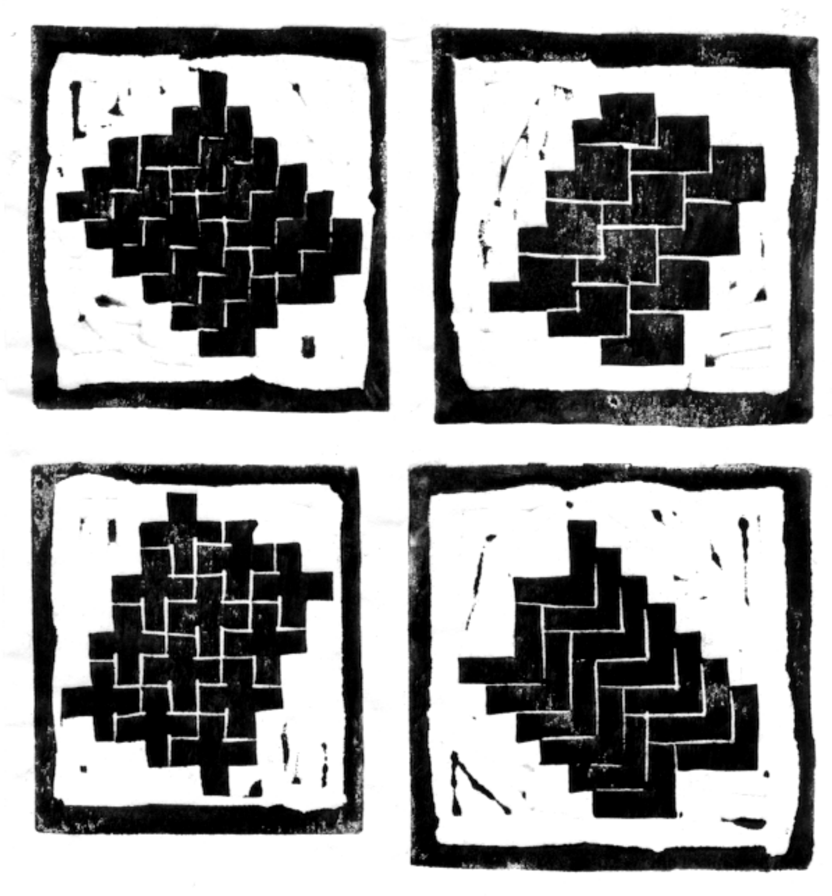


Figure 14

" As I explained in the beginning, the diffraction pattern is the Fourier-transformation of the diffracting object. Consequently, subjecting the diffraction pattern to a second Fourier-transformation, restores the true image of the diffracting object. The process is a lengthy though actually simple mathematical procedure, that need not be explained here. It will be presented in detail in a paper in one of the next issues of the Journal of Atomic Research."

What followed was a firework of esthetic beauty. One poster after another went up showing the crystalline arrays of exat, starat, corat, teat, irat, vat, nat, douwat, lavat, turat, zalat, and parat. All twelve of them (Figure 12 - 14)!

For the first time in history, human eyes saw the atoms, packed tightly by necessity of their shape. And the shape was that of pentominoes!

Haneck missed this historical moment. He was talking to a municipal official about the building of a new lecture hall for Ro'alam University. If Osta was as moved as her audience at this moment, she did not show it, but continued in a sober tone of voice.

"It is remarkable, that in all crystals which we observed so far, the atoms were packed together in a completely space-filling manner. One could conceive of other regular arrays, in which empty spaces are placed periodically in between the atoms. However, we have never seen such crystals. Therefore, the crystals are the densest form of matter observed so far. Another point to be mentioned is the following. Using just paper and pencil, one can come up with alternative periodic arrays of pentominoes. It remains to be seen whether these and other structures actually exist as crystals, and whether the described forms can re-crystallize into alternative forms. "

She paused to look up her notes and then read from a sheet.

"In summary I may say, that all elements can exist in crystalline arrays. In particular we found the following properties of crystals: a. The crystals are two-dimensional, i.e. they are stacked sheets of planar atomic arrays. b. The pentomino shape of the atoms can be seen by Fourier-transformation of the diffraction patterns of X-rays. c. The observed shapes confirm directly the assignment by Dr. Haneck between elements and atomic shapes. d. The atoms in the crystals are the densest packing of matter possible."

She looked up and continued in free speech.

"The last point offered us an opportunity to measure the size of atoms for the first time. Since we know the total amount of, say exat, in a crystal, we can calculate how many atoms the crystal contains. At the same time we know the macroscopic size of the crystal. If we divide that size by the number of atoms, we obtain the size of one atom."

The audience, hardly recovered from the first surprise, struggled to cope with the next. The real size of atoms! My God, how small they were! How structured this smallest, innermost sanctum of nature!

When Osta added that the known size of atoms allowed one to calculate the wavelength of the X-rays that had been used to produce the diffraction patterns, the audience was too overwhelmed to absorb the implications of this additional discovery.

Vibrating patterns

After Bekkel, Haneck and Osta had chosen Ro'alam as the place to present their major discoveries, Ro'alam had became the most prestigious meeting place of science. Only the most established scientists were awarded chairmanships of sessions; only exceptional scientists were invited to present their work. Yet, the organizers never forgot, that Osta had been unknown to the general audience, when she caused one of the greatest sensations in Ro'alam's history. Therefore, it remained a tradition to give young, unknown talents the opportunity to present their work at the Annual Ro'alam Symposia.

It was the fiftieth symposium since Bekkel's time, and the anniversary was celebrated with glamour and dignity. This year's topic was the 'Mechanism of Atomic Bonding', a euphemism for 'Chemistry'. A bit of politics had been involved in the choice. Kekello, the president of Ro'alam University was one of the most influential chemists and he had wanted this symposium for a long time.

When he first became interested in chemistry, people had just discovered the structure of the most important natural compounds, such as water (=TC3, i.e. eat-tri-corat, (Figure 15)), or the diatomic teat T2 in the atmosphere that was commonly called 'oxygen' (Figure 15).

Already at this time the suspicion arose, that exat played a special role, because it formed many polymeric molecules. The suspicion became fact, when Dirre showed that living organisms contained a large number of exat-derived compounds. The most frequent were exacorats, the polymers of exat and corat with the composition formula (EC)n (n=1,2,...). (Figure 16). Soon the term 'organic chemistry' was used instead of 'exat chemistry'. For a while the debates continued about the question whether small, exat-containing molecules should belong to the 'inorganic chemistry' as the rest of chemistry was called by now. For instance, the exat compound that living creatures exhale, the exat-tetra-teat (Figure 17), and the frequently used solvent, called benzara - actually hexa-exat-tetra-corat (Figure 18) - , had been studied as part of general chemistry long before organic chemistry became a separate field.

By now organic chemistry was an established discipline in its own right at most universities, much to the displeasure of Kekello. He could not agree that the chemistry of one particular element should be treated as if it carried the secret of life, whereas the other elements were treated as 'dead' matter. Obviously the other elements such as corat occurred in the living matter as well, if not more frequently. He hoped that this symposium would correct the misconception, and support a new chemistry that dealt with the elements more even-handedly.

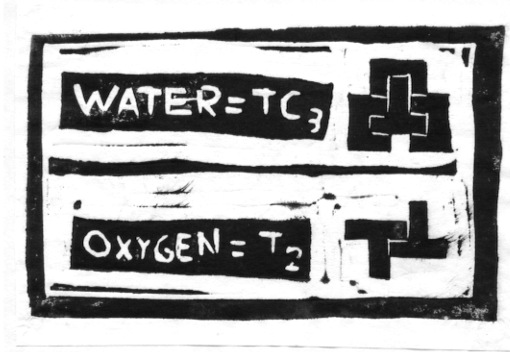


Figure 15 Examples of the molecular structure of common compounds such as water and oxygen.
Figure 16 Example of the molecular structure of the biologically important polymers called exacorats.

Figures 17, 18 Other common compounds such as the exat oxidation product that animals exhale, and the important solvent benzara (Figure 18).

The hot new topics were the so-called 'resonance bonds' between two atoms. In contrast to the classical 'lock-and-key bond' that was based on spatial fitting of the pentomino-shaped atoms, the resonance bond added an aspect of dynamics. Consider a material like platat (Figure 19). The atoms of exat and starat do not merely fit into the compound and thus bind it. They exist in such a special configuration that they can swap places while still binding to each other (Figure 19). It was found that the exchange occurred in reality at the very high frequency of several billion times a second. Consequently, neither of the two configurations was practically ever present in a molecule. Most of the time the resonating bond was in the third state of changing places. Consequently, it had become customary to symbolize a resonating bond by parallel lines, that avoided indicating either of the two extreme states of the bond (Figure 19). The rapid exchanges reduced the repulsive force components between adjacent atoms, thus increasing the strength of the bond.

More and more resonating bonds were found, and by the end of the symposium at least twelve had been experimentally demonstrated (Figure 20).

In view of the discovery of several new resonating bonds and the acceptance of the theory of metal structure, the symposium was a great success in the annals of the Ro'alam Symposia. Yet, Kekello was not happy. Nobody had addressed the question of organic versus inorganic chemistry.

Figure 19 Platat, the compound that led to the discovery of resonance bonds. The pair of starat and exat can flip around without disturbing the rest of the molecule. It was found that such configurations of two atoms, indeed, change places billions of times every second, thus producing a this new type of bond. It is symbolized with a set of parallel lines.

Based on the idea of resonance bonds, people could begin to make sense of the properties of metals. As it turned out and many of the related observations were presented at the symposium - all metals were crystalline arrays of resonating pairs. In this way the resonances reached macroscopic dimensions, as waves of place-changes raced back and forth throughout the entire material, thus giving it the properties of metallic reflection and electrical conductivity. For instance the resonance bond between turat and nat generated the metallic character of copper (Figure 21), the resonance between teat and starat that of aluminum and the resonance between lavat and turat was responsible for the metallic properties of iron and so forth (Figure 21).

Glittering riddles

"Why are you so hard on these people?"

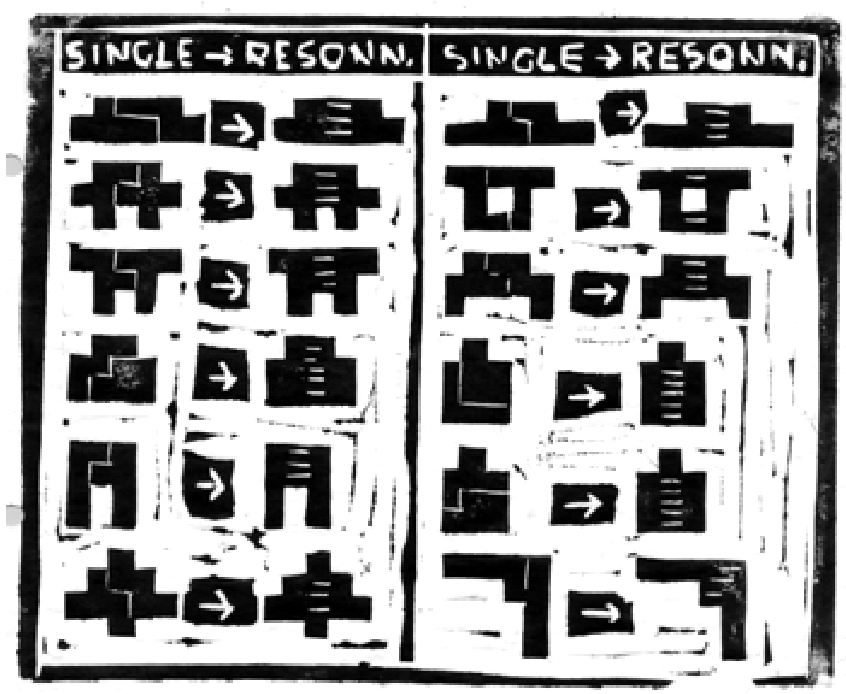


Figure 20 List of the most important naturally occurring resonance bonds.

Kekello and Ferris were discussing the results of the symposium over a cup of coffee. As much as the faculty of Ro'alam University was proud of the reputation of their symposia, at the end of one a sigh of relief spread across campus. After months of preparation, after the strain of the daily events and demands of the participants merry and

relaxed faces returned to campus. People sat together like soldiers after a battle, at peace and detached. Almost a whole year of undisturbed work lay ahead of them, before the next symposium came roaring in. If a symposium had been as successful as the most recent one, the atmosphere was particularly friendly. Most participants had left with good feelings, and the faculty enjoyed a sense of accomplishment.

Ferris in his most complacent mood could not understand Kekello's anger.

"Don't you see what they are doing?" Kekello shook his head. "There is no difference between the chemistry of life and the chemistry of dead matter. Obviously, living objects convert into dead ones and vice versa, without ever changing the laws of chemistry."

"I agree", said Ferris. "But who cares about names? In fact, these people work more for your cause than you seem to realize."

"Oh, really?" Kekello asked mockingly.

"Look, they are about to demonstrate, that there is nothing but chemistry going on inside cells. What makes cells so special, are the particular chemical compounds in them. Not special laws of chemistry."

"You know that, and I know that" said Kekello, "but wait a decade or so. By then they will be too specialized to remember. Like vines, they will overgrow every rational thought with their 'biological' attitude. First it's specialization, than it's exclusion of everything else."

"We should think more about proteins.", suggested Ferris, hoping to disarm his attacks.

It took Kekello a little time to change in his mind to another subject, but Ferris was right. There was a fascinating chemical problem to be solved. All proteins seemed to be rectangular flakes. They all measured 6x10 Ostas. Yet, different proteins showed different chemical reactions with other compounds. In addition, it was fascinating to imagine the interior of a cell as an underwater scene. There were the fibrous strands of exacorats floating like seaweed. In between them glittered myriads of little rectangles, the proteins, like shoals of fish, all swirling around the huge spherical monster, the nucleus with all the nucleats inside. Anyway, it was time somebody figured out why the little rectangles had any chemistry at all. Obviously, their smooth sides did not offer any particular reactive nooks or noses for other atoms to bind. A good chemist had to solve the problem, before these romantic biological chemists had proposed another of their special 'mechanisms of life'.

A comet rises

'The rat!' Burr was furious. 'How could Miseke run around with other people's data? Oh, sure, he would mention his source at some inconspicuous occasion, so that nobody could remember it. Now he had done it to him, to Burr, to his lab-chief. Miseke had boasted with Burr's latest data to Kekello of all people!

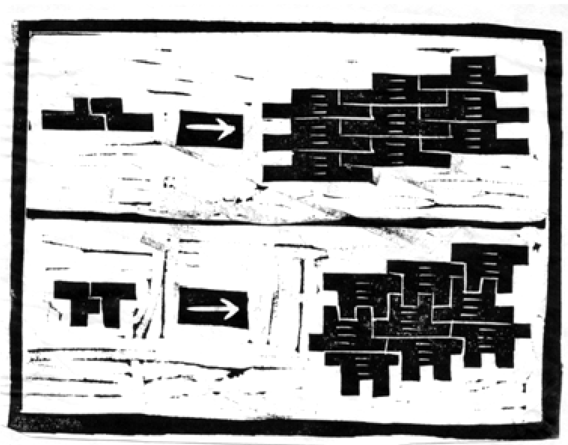


Figure 21 Examples of resonance bonds that are the basis of the optical and electrical properties of metals. The upper panel shows the structure of copper which is formed from nat-turat resonance pairs. The lower panel illustrates the structure of aluminium as it is composed of teat-starat pairs.

Kekello did not pay much attention to questions of credit. If it was a real breakthrough, he argued, there would be no question about authorship, because the acceptance of real breakthroughs requires battles with the peers, that only the author is willing to endure. And if it is not a breakthrough, who cares? Burr, however, saw it differently. He had not achieved a breakthrough, yet. There was always the possibility, that a harmless observation became important, wasn't there? Besides, it was easy for Kekello to stand above such mundane desires like a promotion, a new job, possibly with tenure. Kekello was the president; Kekello had the National Award; Kekello was a member of the Academy; Kekello decided Burr's future.

There were quite a few 'Burrs' in Kekello's laboratory. They hoped for a sign of appreciation. They felt that their presence in one of the most prestigious laboratories of one of the most prestigious universities was worth the back-biting. The place almost guaranteed public recognition of their work. The chances for a good job were much increased by a letter of recommendation from Ro'alam University. On the other hand, the fight was tough, because they were all equally strong. It was even tougher, because Kekello had threatened to fire anybody who put personal ambition before science. Therefore, the fight had turned underground.

Favorite techniques were the 'slip-of-the-tongue':"... I didn't mean to say that at all. It's only that a number of students have complained... ". Then there was the 'inversion-trick': "I am outraged at the accusation that X works with questionable material. A bad batch can happen to everybody. I am convinced, that he publishes only the experiments with proper material...". Another effective approach was the 'devaluation by rumor': "... It seems that Perst is not going to offer her the job. I heard that some members of the faculty didn't believe her data. Stupid, isn't it? Anyway, I am glad that this way we are not loosing her... ". At times, the 'mutual-recommendation' seemed in place: "... Have you seen X's latest data. They are spectacular... Uh, he told you about mine? Well, they are really not that important..". The frequent 'deep-concern' attitude ran like this: "... I hate to bring this up, but I get more and more concerned, that the unfortunate conflict between X and some Members of the Academy, will eventually hurt...". There were also brutal 'push-and-shovel techniques to attract attention, that need not be described here.

One of the more sneaky ones was the trick that Miseke had just played on Burr. Having no data of his own to report, he told Kekello the latest findings of Burr's. In view of Kekello's indifference toward credit, Miseke could be sure that Kekello's memory would somehow associate him with Burr's new data. Burr on the other hand could not tell his new data a second time without leaving the impression in Kekello's mind that he was a bore, talking about facts that Kekello already knew.

Burr knew that it was an important result to find that the element turat was contained in the protein globat. If there was a secret to the process of life, it should be contained in proteins. The first who unravelled the mysteries of these ubiquitous rectangles was sure to solve a major question of biological chemistry. Therefore, Kekello had put all his resources behind this project. Progress in the project, no matter how small, was sure to capture his attention. Hell, Miseke would pay for it. Unfortunately, Burr could not do much about it right now, because Kekello wanted everybody to collaborate with everybody else in order to speed up progress.

"Miseke told me about turat." said Kekello. "I think we are well on our way. I also think, it would be a good idea to test all other elements. There are only six that have not yet been demonstrated in globat, am I right?"

Burr was eager to answer.

"This is exactly what I thought. After I had found the turat, I suggested to Miseke to search for douwat, too. I don't know whether he has any results as yet..."

"No, I don't want him to do that" interrupted Kekello. "Why don't you go on with that approach? You are better equipped for it, anyway, aren't you?"

Burr saw Miseke grin, and nodded without words. Kekello continued.

"Maybe Miseke should go to Londov for a month or so, and find out what Maxoe is doing. It's a nice trip." He turned to Miseke directly. "And Maxoe is worth knowing. Have you been to Londov before?"

"No," said Miseke. "I would love to. I just think that Burr might be more qualified. He is my senior and knows more about protein chemistry than I do."

"That's why I want him here." Kekello smiled at Burr, who was torn between the pleasure of being acknowledged by Kekello and the anger that Miseke had just beaten him in a major political move. Kekello stood up, and both followed.

"Why is Maxoe working on albumat? Do you think it is a better choice than globat?"

"Absolutely not", Burr was sure.

"Albumat is much less enriched in liver cells than globat in blood cells. At some point Maxoe must run into terrible problems of contaminants. I think, we are far ahead by using globat."

Two weeks later Miseke left for Londov. Kekello had arranged a well-paying and reputable fellowship for him, that meant a great deal of future credit and recognition for Miseke, no matter what the results of his 'espionage' mission were. Burr decided on a counter-measure, namely to put Limus up for promotion, the person Miseke hated the most. Upon his return, Miseke would find himself on the same level with Limus. Provided Miseke was not too successful in Londov, in which case Kekello might promote him...

They all were wrong. Maxoe was far ahead of them. He had managed to grow protein crystals, and using Osta's diffraction method he had obtained the most breathtaking, beautiful images of the first protein. His structure of albumat swept across the planet leaving everybody gaping: A rectangle of 6x10 Ostas that contained one atom of each element in the most logical, space-filling pattern (Figure 22).

Light above the trenches

Losing the race was not too hard on Kekello. After all he had already won a National Award for the structure of benzara, and had earned the presidency of Ro'alam University. It was a bit embarrassing, though, because his research facilities and manpower exceeded Maxoe's by far, and his starting material, globat, was much more promising than Maxoe's albumat. And yet, as the snail had said, handicap is the greatest blessing. It had forced Maxoe to try courageous ways that the self-assured collaborators of Kekello's and their famous leader would have rejected.

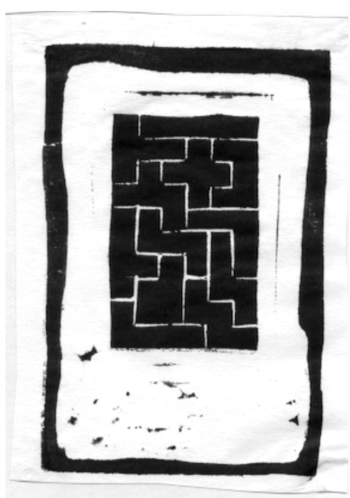


Figure 22 The first known structure of a protein, namely albumat as discovered by Maxoe. Each protein is the mathematical fit of all twelve different atoms into a rectangle with the sides 6 and 10.

There are many such possibilities, but each has an astronomically small probability of occurring by chance.

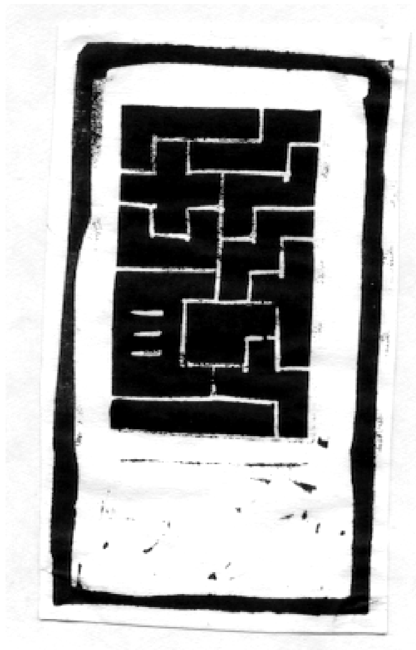


Figure 23 Globat, another protein which contains a resonance pair.

The situation was less amusing, though, for people like Burr. Their work of several years was largely obsolete. One or the other chance observation or experimental method was still useful, but they were too depressed and also too single-minded to recognize it now. More than ever they were at Kekello's mercy, now that they had nothing to show for themselves that would lead to a promotion within the University or to an attractive offer elsewhere.

Miseke turned out to profit the most. Since Maxoe had trained him in the new methods of protein crystallization and Osta-diffraction of protein crystals that had led to the discovery, he returned from his sabbatical to Ro'alam University as one of the few expert in this hot new field. Of course, Kekello offered him the chairmanship of the new Department of Protein Structure, a position much higher than Burr ever had. Quickly Miseke set out to complete the job they had started together. Within a few month he published the globat structure. The sensation was understandably not as great as the one Maxoe had caused. However, he could take credit for an important new piece of information, namely that globat was built just like albumat: one atom of each element fit tightly in a 6x10 Osta rectangle (Figure 23). In addition, it had one teat-vat resonance-bond.

There were a number of other similarities between the two protein structures. For instance, in both molecules one nose of the exat atom was inserted into the nook of the corat atom. Considering that exacorats were a major component of living matter, the result pointed to the possibility that exacorats were involved in protein synthesis. Yet, people were reluctant to generalize anything at this stage. At least a couple more protein structures had to be known before one could attempt to suggest general rules of the association between atoms within proteins.

Miseke was determined to provide the structure of every protein, he could purify. He had the necessary equipment, the manpower, a head start, a hunger for power, and was uninhibited by imagination. The ideal man for the job. And he succeeded. For years to come, students of protein structure chemistry would train in his department and leave with excellent jobs offers from other places.

Maxoe could have done the same job at Londov University, but he was much too creative for the repetition of even his own work. Of course, he won the National Award for the albumat structure, but that was more a nuisance than an honor for him. The following flood of invitations to speak and to contribute chapters and articles to books and journals interfered very much with his passionate interest in ancient music. And so he began to turn down one honorary degree after another, to 'forget' invitations he had accepted, until the public gave up and turned to Miseke for a willing chest on which to pin medals. And they found no resistance there.

Yet, Maxoe did not leave science. On the contrary, with renewed energy he turned to one of the major questions that his work had not answered. How did these beautifully structured rectangles react with anything, let alone with each other?

Two possibilities were discussed. In one type of model the interacting protein molecules were supposed to have a weak configuration of atoms at a particular edge location. The protagonists of this 'edge-model' speculated that this group of atoms fell off if the right other molecule bumped into it, thus opening up a ragged - thus chemically reactive - outline. (Figure 24) The opponents of this model were quick to point out its major weakness: Why should another molecule interact strongly with this ragged outline, if it was not strong enough to hold its own - perfectly fitting - group in place?

They proposed an alternative model that introduced the third dimension. All chemistry known so far had happened in a plane. The pentomino-shaped atoms interacted 'sideways' within molecules. But, what about their upper and lower faces? Why should it no be possible to stack molecules above each other? Perhaps there was a new type of 'vertical' inter-atomic force. If it existed, it had to be much weaker than the 'horizontal' bond, otherwise the known 'flat' compounds could not be stable. Yet, it was conceivable that such weak bonds added up in a molecule as large as a protein and provided a sufficiently firm basis for vertical interaction. This model was called the 'stack' - model (Figure 25), although its opponents preferred other names like the 'belly-up'-model. Of course, its major weakness was the fact that no vertical interactions between atoms had ever been observed.

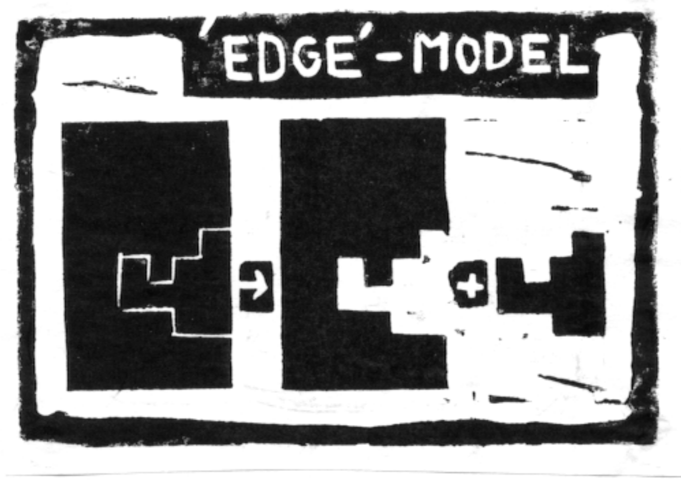


Figure 24 One of the two competing models of protein interaction with other molecules:
The 'edge'-model assumes that reactive groups can break out of a rectangular protein molecule. Subsequently, the resulting gap can interact very specifically with another compound that fits the gap exactly.

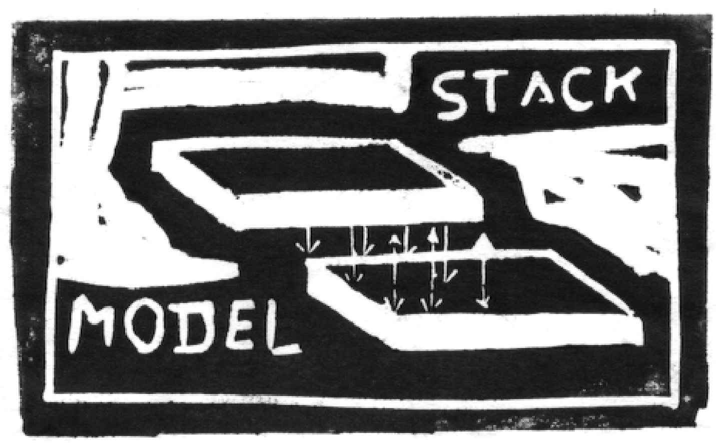


Figure 25 Alternative model, the 'stack'-model which assumes that the interaction are vertical between the rectangle of the protein and another protein or another compound. The latter turns out to be true: The specificity of protein action is based on vertical resonance bonds as discovered by Kekello.

The argument did not impress Maxoe very much. He contended that vertical forces had, indeed, been observed. How else could resonance-bonds work? He argued that they cannot switch places without leaving the plane of the molecule. And while they left the plane, and yet stayed bound to the molecule, they were held in place by some vertical force... quod erat demonstrandum.

In praise of excellence.

"I think we can begin. Kekello told me that he would be late, because of the Ambassador's visit. Is everybody else here?" Carpas, the chairman of the Promotions Committee looked around the conference room. Nobody seemed to miss anybody, and Carpas continued, "Has everybody received a copy of the folder on Dr. Miseke?"

Some nodded, others were obviously reading it. They had not studied it earlier and made a last minute attempt to find out how many papers Miseke had published and how much governmental support his research had received. It was also important to get some better ideas on the subject of his work before the discussion about his merits began.

Carpas opened his folder.

"Dr. Miseke is up for promotion to Full Professor. You have in front of you his curriculum vitae, a statement about his research plans..."

Pasan, the chairman of pathology interrupted him. "I lost mine. Can I have another copy?"

Carpas found one, handed it to him across the table and continued. "You should also have copies of six letters of recommendation. Finally, there is a statement from Kekello evaluating Dr. Miseke's performance while he worked in his laboratory. Does everybody have all the documents?"

Since nobody answered the question, Pasan opened the debate. As usual, he twirled his hair while he spoke.

"I have no doubt about the qualification of Dr. Miseke. The letters of recommendation are enthusiastic and most flattering. Of course, his record as a researcher is impeccable. He has substantial national and international visibility. I think, there cannot be any doubt, that he deserves promotion. My only concern is his age. He seems very young for the position, and I was wondering, whether we shouldn't wait..."

"And loose him to Londov?!", interrupted Ress. "They will go out of their way to get him. They are really unhappy with Maxoe, no matter how famous he is. He is so uncooperative. He doesn't do any public relations work for them. No fund raising, nothing. Miseke would be ideal for them."

"Did they make him an offer?" asked Pasan.

"I don't know for sure," answered Ress. "But, the last time I met their chairman of biochemistry - I believe her name is Berto, or something - she joked about it, although I think she meant it."

"I think we should not let our decision be influenced by any outside offers." objected Carpas. "We have to decide for ourselves. Let's quickly review the requirements for the promotion. Any comments on Dr. Miseke's teaching ability, his past performance as a colleague? I haven't got any student ratings on him." He looked again from face to face, but nobody seemed interested to speak.

"Will he need more space?" asked the chief of dermatology whose laboratories were on the same floor as Miseke's.

"I asked him," said Carpas, "He seemed quite happy with what he has, which is actually quite large. Besides, only two years ago we equipped his entire lab for protein structure analysis. So, I think he is quite content in this respect."

At this moment, Kekello came in, and apologized for his tardiness.

"Politicians are really a species by themselves." he said referring to the Ambassador. "It is impossible, to get any answers out of them."

"So, the money from the Research Funding Agreement is still up in the air?", asked Ress.

"I honestly don't know." said Kekello. "He said all kinds of wonderful things about the RFA, and what 'substantial influence on the maintenance of scientific excellence in both our countries' it represents but nothing tangible." He shrugged his shoulders. "Next month, I'll be at the meeting of the International Research Council, and hopefully I can find out more. We definitely need the funds. Otherwise we cannot fill all the positions we need."

"I am sorry," said Pasan, "but I have to be at the seminar of a job candidate for our department in half an hour. Can we go on with our business?"

Kekello did not like to be accused of chatting.

"Sure." he said abruptly. "So, what about Miseke? Are there any problems with his promotion?" "No," Carpas assured him. "We were just discussing the space he may or may not need. Do you have any information."

"He has plenty." said Kekello. "If he wants one more square foot, he can have mine in his backside." They laughed.

"Let me raise once more the question of his age. Even if we all agree, that his young age doesn't matter, what about his peers? What about Burr, for example? Wouldn't we generate a bad situation..."

"For Heaven's sake!" Kekello's voice was shrill. "Who cares? If Burr would have produced half of what Miseke did, we would promote him, too. It's just too bad, but excellence wins in science. Miseke found the structure of globat. Burr found nothing. Miseke teaches a large number of students the latest techniques of Osta-diffraction. What does Burr do? Look, if anything, we have to get the message out, that around here seniority does not matter, but excellence and performance matter. That's the only way in which we can attract the best young people. "

"That's absolutely right", said Ress. "We depend more and more on outside funds. Without excellent young talents, we won't be competitive. I'd rather pay two young Assistant Professors than one Associate Professor like Burr."

"Is Miseke going to be involved in the RFA project?" asked Carpas.

"Of course," answered Kekello. "He is a major part of the application. Without his protein structure section the whole thing could not fly. With him, it is a true collaborative project, that looks at cell division from all angles. Without him, we will never get the money from the RFA."

"Which means that we have no choice, but to promote him." said Pasan in an aggressive tone of voice.

"We did not have much choice with your candidate, either." retorted Kekello coldly.

Ress tried to change the subject, before Kekello and Pasan started one of their confrontations. "Miseke's promotion means a raise for him. Where does the money come from?"

"Half from us, half from dermatology." answered Kekello.

"He has a joint appointment with dermatology, remember?"

The chief of dermatology looked up in utter surprise. "I have nothing left on my budget. What are you talking about? This joint appointment was a technicality to give Miseke access to biopsy material, but nobody said anything about salary commitments."

Kekello looked disgusted. "You wanted me to pay your teaching assistants for the lab course. I understood that in return you would pay half of Miseke's raise. If you can't, I have to take back the money for the teaching assistants. I am sorry. "

The tension in the room was strong enough to explode any second. Ress tried again to step in between. Why did Kekello always antagonize everybody?

"Bassdo is retiring. His replacement must be younger person, and therefore we can save some salary money which can go to Miseke."

Kekello was still growling, but Ress had a point.

"Alright then," Carpas tried to adjourn the meeting. "Is it settled then? Is there a motion to promote Miseke to Full Professor as of next quarter? Anybody second the motion? All in favour say 'Aye'. The motion is carried unanimously."

The sound of the gavel made Pasan cringe.

The inner waves

"Wonderful", said Kekello sarcastically. "What a neat idea!". Miseke had just returned from another visit to Londov, and reported on Maxoe's latest hypothesis about the specificity of proteins. He had explained how vertical bonding forces between a protein and another substance led to their interaction. He had presented Maxoe's speculation that two protein molecules could interact quite specifically if they shared a common configuration of atoms.

Kekello' s voice was sharp and angry. Miseke knew all too well what was coming. "Where have we come to? Are we beginning to dream up the facts of nature, in order to cover up our ignorance?"

He shouted. Miseke held still. Nothing could stop Kekello now.

"Would, please, anybody explain to me how this sublime theory of Maxoe's deals with the following fact. The protein, that has the largest number of configurations in common with e.g. globat is globat itself! All globat molecules should stick to each other like hell, shouldn't they? But let me tell you something. They don't!! That is an experimental fact, not a figment of proteinacious dreams! In fact, every protein should stick like hell to its own kind, shouldn't it?"

He caught his breath, but he wasn't finished.

"Is there no limit to the mindless imitation of Bekkel? Not everything is nature must be explained by its shape. God! These people hear the word shape, and turn off their brains immediately. With glassy eyes, and no thoughts, they sweat out 'explanations' and 'hypotheses'!"

Miseke never understood how somebody could get so excited about science. Kekello was shaking in anger. Perhaps there was a remnant of envy for Maxoe's victory after all... Whatever the reason, it was best to remain quiet, and to let it blow over. Tomorrow Kekello would be alright again.

Finally, Kekello realized that he was yelling at the wrong person and slammed the door behind him.

He had a point, though. Why did the same proteins not always stick to each other? Of course, Maxoe had thought about that question, too. It was unfortunate that Miseke had been the messenger for an idea, that was much more sophisticated that Miseke had understood.

Admittedly, for a while Maxoe had thought that all vertical forces would be attractive. It would have been too beautiful! Imagine, how simple protein replication would be: Each protein molecule became its own template. The twelve different atoms sticking to the surface of a protein rectangle by these vertical attractive forces would automatically duplicate every detail of the molecule.

Too bad, that it had to be wrong. Otherwise, similar molecules should always bind to each other, which was simply not the case. There had to be repulsive vertical forces. Yet, which configuration was attractive and which was repulsive?

When the answer came,- this time Kekello was the first to find it - the secret of specificity of protein interaction appeared simple, elegant and embarrassingly obvious: Two protein molecules repelled each other unless they could form resonance bonds in the vertical direction which they could not form in the horizontal plane of their own rectangle.

THE INNER LIMITS

Fear and chaos

The war between the Northern Province and the Central Range spread like wildfire through the civilized countries. And it was fuelled in part by the progress of science, whose greater insight into nature turned its monstrous side for the first time! Before the age of science, the waring countries fought battles whose destructive power was limited by human fatigue. Now the machines of science were fighting, never fatiguing and much more efficient at destruction.

Science provided the counter-measures as well. So, it was praised for its power to protect humans from the enemy's evil scientific weapons. From explosion to explosion mankind fled towards a world where science's threats and science's shelters neutralized each other at the expense of human balance.

Another early impact of science came to full blossom. Its novelty could dispense with the requirements of century-long traditions that were kept in families and countries. Anybody could become a successful scientist, regardless of family background. A burst of new talent of laborers' and farmers' children swept the nations. Not only could they develop their skills without the intimidation, frustration and unfairness of lacking 'the right background'. What they built was brilliant and powerful, and it placed them high above those who had 'the right background'. Those sons and daughters who had expected a comfortable, ruling life amidst their precious heirlooms, lost most of their possessions in the war. Their cultural heritage was of little use in the competition with the new leaders, who were rude, energetic, addicted to facts, oblivious of the existence of philosophy and art - so frighteningly similar to the founding ancestors of the 'families with the right background'.

The new rulers derived their strength not from inheritance but from innovation. They created where others had only applied. And they showed the disturbing features of creative minds: chaos and fear. Ironically, many of them hoped to earn an old-fashioned life surrounded by works of art in aged, peaceful, ivy-covered mansions. Yet, their every successful transformation of science into new technologies that brought them the desired wealth in order to establish the dream, removed it further from reality, because it moved the world closer to a future world without such mansions.

The Northern Province won the war, but the upheaval continued. The war had not only unleashed the talents of the masses, but had allowed the spreading of ignorance and old fears throughout the countries as well. Post-war poverty, crime and confusion over the new values spawned hideous genocide in the name of science. Evil had reached out for the power of science never to let go again.

A humble carriage

Without Robta Hessin would never have turned the clarity of pentomino-elements into the profound mystery that would bring human understanding to its limits. Only a mind like Robta's would encourage, praise and sooth the panicked discoverer of the ultimate paradox, of the insight into nature that proved the impossibility of ever fathoming her.

Hessin himself did not know for which strange goal he was heading. At first his project seemed quite harmless and actually rather unimaginative. Robta wanted him to isolate the sub-cubes from which all elements were made. Ever since Hulle had discovered the disintegration of certain elements at the critical temperature, sub-cubes had been isolated and measured many times. Consequently, Hessin was initially irritated about his dull assignment and looked for more exciting things to do. But Robta was stubborn. He liked accuracy, and found it shameful that the atomic weight of the sub-cubes was still inaccurate on the second decimal point. He wanted certainty. Their weight was supposed to be 0.20 precisely, and not as reported 0.22 ± 0.05.

Hessin was to eliminate this fuzzy piece of information once and for all. Of course he feared that nobody would reward their work. No matter how complicated the measurements with better accuracy could become - and it seemed that would be very complicated, indeed, - everybody would consider them as boring confirmations. 'Why did you measure, what we know anyway? Why the effort to develop entirely new methods to prove the known? Typical Robta! No vision, no momentum, just nose-to-the-grindstone!"

Right or wrong as they might have been about Robta, they were very wrong about one thing: They did not know the weight of the sub-cubes.

The dance within

Hessin was determined to become famous. He could not stay behind his two brothers who were already in executive positions of the family's company, while he was still the post-doctoral fellow of Robta's. His brothers supervised at least fifty employees while he was subordinate to a man who did not own his home, spent his vacation in a near-by village, and did not know the names of the drinks offered to him.

Many scientists lived similarly dull lives as Robta. On the other hand, famous scientists like Haneck or Bekkel were the pride of their countries. After the war it was clear that great power could come from the scientific mind. Undoubtedly, as a famous scientist, Hessin would be able to match his brothers' success.

Still, there was quite a way to go. A long time of apprenticeship loomed ahead of him. There was so much to learn, so many ways to try, and no success guaranteed or even likely to occur. Hessin had thought that his chances were good, because he had been a top student. Unfortunately, this expectation proved wrong. Good grades in school implied that a student excelled in many topics not necessarily related to science. Even more devastating was the recognition that everybody in science had been an outstanding student, anyway.

There was hope, though. The scientists around Hessin, including his teacher Robta, were reassuringly untrained in the finer skills of competition. These people did not know exactly how to seduce, flatter, plant false information, and stage misleading manoeuvres. Hessin had learned these strategies from childhood on and he was determined to use his advantage if everything else failed. For him science was just another market to be conquered by whatever means necessary. For the time being, however, his skills demanded to play along in the humble ways of post-docs. He knew from his upbringing, that it was alright to start in the mail-room, as long as one was determined to own the company some day. Alright then, let's shatter atoms and weigh the fragments! But not in the well-known ways, of course. Remember, if you confirm old knowledge in a new way you become famous in science!...

If he was lucky, the weight of the fragments might become crucial for an important question. In the years since Menda's discovery of the sub-cubes, people had wondered about the forces between the cubes within individual pentominoes, as opposed to the forces between different pentominoes. Obviously, the forces that held the five cubes of a pentomino-shaped atom in place had to be much stronger than the forces with which two different pentomino-shaped atoms interacted. Otherwise, chemically bound atoms might lose their pentomino shape as soon as they bound to another. Consequently, theoreticians had postulated the existence of linker particles, which were called 'gluons'. According to their notions there were at least two kinds of gluons. One kind, usually symbolized by a circle was held responsible for the intra-atomic force between individual cubes within an atom, such as the starat atom (Fig.26). It was called the 'O-gluon'. The other kind was supposed to act between adjacent cubes of different atoms. For example, a starat-parat molecule was held together by four such gluons, that were called 'X-gluons' (Fig. 27). They bound the cubes of the starat atom to the cubes of the parat atom.

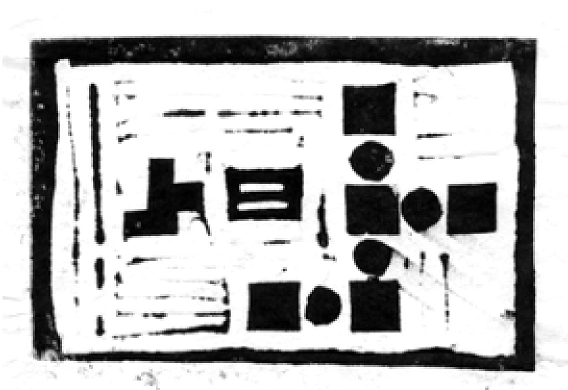


Figure 26 After Hulle's early discovery that atoms can be fragmented, the question remains how the pentomino shaped atoms are structured internally. The gluon-theory is the most widely accepted idea, which assumes that each pentomino consists of fundamental cubes held together by weightless so-called O-gluons. The figure illustrates the concept in toe case of a starat atom.

In order to explain resonance bonds, the gluons were assumed to be weightless, and able to jump between cubes like electric sparks between electrodes. Considering again the example of the starat-parat molecule, that actually is a resonance bond, people hypothesized that certain O-gluons could swap places with certain X-gluons in order to produce the alternate configuration without any cubes moving physically around (Fig. 27). The idea was attractive, because it seemed easier to understand how weightless gluons jumped around at high frequencies in a resonance bond, than to imagine how weighty cubes or even whole atoms were spinning and leaping. In addition, one could now understand how a resonance-bond could function without any atoms jumping out of the plane of the molecule.

Nevertheless, the gluon-theory had its problems, too. For instance, how could the O-gluons so easily swap places with X-gluons if the O-gluons mediated the much stronger forces? Also, if they were swapping places between cubes, why between some and not between others? No satisfactory theory had offered simple rules that would govern the leaping and exchange of gluons. Most difficult, though, was to explain how O-gluons gave rise to pentomino shapes. Why did they always unite five cubes, and not six or seven or three? So far all attempts to explain pentomino shapes by the properties of gluons had ended in a mess of auxiliary rules and exceptions that defeated every intention of finding simple explanation of the most fundamental laws of Nature, namely the laws of intra-atomic, and inter-atomic forces.

Hessin was not too troubled by theoretical problems. He agreed with Robta, that theories were premature as long as the exact weight of the cubes was unknown. Just imagine, that their weight turned out different from 1/5 = 0.2 ! Perhaps the gluons weighed something after all. In fact, Hessin became quite excited with the idea that his project might demonstrate that gluons weighed something. That would make him famous for sure.

The interruption

When Calpon entered Robta's office, he immediately saw his manuscript in the middle of the desk among Robta's neatly ordered stacks of paper. Robta stopped reading it and turned around.

"Sit down."

Calpon was very anxious to hear Robta's reaction. His first paper on the isotherms of Zalat was the result of almost two years of work. The data were good and significant, he was sure. The writing of the paper had taken more than three months and five different versions. In the end, he had memorized the text too well to be able to detect any more places which needed improvement. Considering the effort, though, it had to be a good paper. Calpon was proud of it, although he knew that Robta would find one or the other fault.

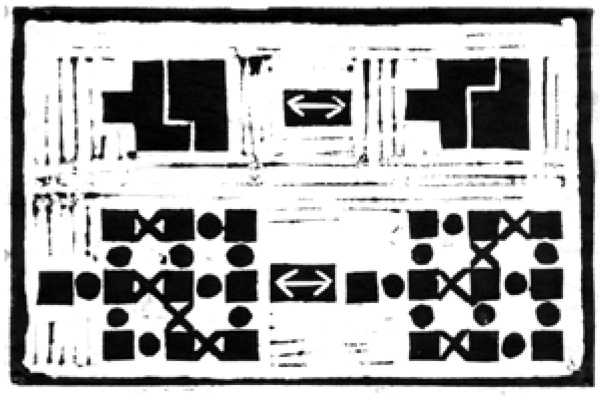


Figure 27 In order to explain the binding between different atoms, the gluon-theory postulates a second, 'weaker' kind of gluon which bind the cubes of different atoms together. It is called the X-gluon. The Figure illustrates how a starat-parat resonance bond is structurally explained by the gluon theory. In particular, it shows that the rapid oscillations of the two atoms do not require that the atoms move physically. It is obviously sufficient that three X-gluons change place with three O-gluons. Since all gluons are assumed to be free of mass it could explain the high frequency of resonance that did not use any energy.

"I finally had a chance to read your manuscript. Basically, your data are sound. There are few control experiments missing. You will have to do some more work. But your writing is unacceptable. You can't publish your results in this way." said Robta closing the manuscript and opening it again at the beginning. Calpon's heart dropped.

"But, I thought.." he began.

"There are problems of language and construction, and I come to them later. The major problem, however, is one of attitude. You write in an unprofessional, condescending,... I don't know how to call it... way. In many cases you overexplain, in others you speak in lab-jargon as if you were so famous that everybody was familiar with your work. The construction is rather confused. Parts of the Result section appear in the Discussion, the Summary gives no explanation of the reason for the project, and so on and so forth." He looked up, and saw Calpon's pale face.

"We all need to learn how to write papers. Don't feel bad. It is a difficult task to find the right measure of accuracy, enthusiasm, objectivity, logic and explanation. I went through quite a few such sessions with my teacher."

Calpon still looked very hurt, and Robta added, "The substance of the paper is good, you know, it is mostly the writing. Let's go through it from the beginning. The title 'Isotherm Inversion' is lab jargon. Isotherms cannot be inverted, do you see that? What you mean is that the slope of the isotherm changed from a negative to a positive value."

Calpon nodded, and Robta continued, "So, what would be a better title?"

Calpon thought for a while. "'The occurrence of a positive slope in the isotherm of zalat," he suggested.

"It is better, particularly because you told the reader what element we are talking about. But, be honest, would you be very interested to read a paper with this title?" Robta smiled facetiously, referring to Calpon's laziness to read. "The title of a paper should divulge a little of its meaning. It should provoke the reader a bit."

Calpon tried again. "'The onset of atomic fragmentation as expressed in the positive slope of the zalat isotherm.'"

"Very good." Robta was visibly pleased, "Now try to say the same more concisely. Don't get stuck with the word 'isotherm'. Try to get rid of it. What is the positive slope of an isotherm?"

"You mean 'negative compressibility'?" asked Calpon.

"Exactly. Now try again."

"'The onset of atomic fragmentation as expressed in a negative compressibility of zalat. Calpon had regained some of his self-confidence.

"It still stumbles.", objected Robta. "'How about' Negative compressibility of zalat reveals the onset of atomic fragmentation.'?" He looked at Calpon, who seemed to like the title.

"Now, let's turn to the Abstract. You start with the following sentence. 'The isotherms of zalat were measured in a Menda-apparatus near the point of decomposition of its atoms. We found that...' Again the same question as before: Would you know why you as a reader should be interested in all that?"

Calpon had to admit that he would probably would not know why he should read the paper.

"Explain first why you did the experiments. For example, you could begin in this way. 'At the onset of atomic fragmentation elements in the plasma state must increase their volume. Therefore the coefficient of compression can be expected to assume negative values in the neighborhood of the critical temperature. We measured the isotherms of zalat in a Menda-apparatus at near-critical conditions, and found, indeed, that..' Do you see the difference?"

Calpon certainly could see it. He reached for the manuscript with an embarrassed expression. "I see it now. Let me rewrite it."

"Alright." said Robta. "But we also have to talk about the experiments. There is an important control experiment missing. You argue that the critical conditions for atomic fragmentation are different for different elements. Therefore, the size of the temperature interval in which zalat has negative compressibility may be artificially extended by impurities. I agree. It is a valid argument, but you never show it. Why not add deliberately a small amount of exat into the zalat and measure..."

He could not finish his sentence, because Hessin stormed into the room with an almost insane expression on his face.

"You have to see this. Everybody is wrong. Menda is wrong, Hulle is wrong. The whole theory of atoms is wrong. There are no atoms, no pentominoes. Quickly come."

The needle stuck in the rill

The new heating and counting devices which were developed during the war had simplified Hessin's task tremendously. With their help the superheating of elements was much more reproducible. The desired temperatures could be reached much faster and more accurately. They could be stabilized for longer periods of time. The resulting atomic fragments could be counted using their electromagnetic properties in new and faster ways. Most importantly, however, much larger numbers of fragments could be counted in each experiment, thus yielding a greatly improved statistical accuracy. The result is well-known. The atomic weight of the sub-cubes was not 1/5 = 0.200 but it was 0.224 ± 0.005 (!)

The shock reverberated around the scientific world. How could it be? All atoms were undoubtedly pentominoes with the same atomic weight of 1.000. Yet, the weight of five sub-cubes would become 1.12 ± 0.02. How could the sum of the fragments be heavier than the whole?

A tide of hypotheses followed that tried to resolve the paradox without sacrificing the pentomino-concept. Oppis suggested a scheme of gluon weights that had the curious property of changing within an atom. Pappaca proposed a process of fragmentation of atoms that left several gluons attached to the sub-cubes, increasing their weights accordingly. Gekmannee published the hypothesis that every preparation of isolated sub-cubes inevitably contained aggregated sub-cubes that increased the apparent average weight.

All these suggestions were discarded, because they required too many ad hoc assumptions, and violated the principle of simplicity in science. Obviously further experimentation was required before any more hypotheses should be considered.

Hessin was finally famous. He basked in the warmth of the attention and the envy around, but became increasingly complacent and weak. To his credit and the credit of his upbringing it must be said that he realized quickly his downward movement. Offspring from his family were expected to know how to handle success.

Another factor in his recovery was the way, Robta looked at him. No, Robta was not envious. He was startled about Hessin's finding and his outburst of shallowness. Nevertheless, he encouraged Hessin to continue his work on the fragments while he shied away from him as a person. He was supportive, while puzzling how an encounter with mystery could turn up so much vanity in a person.

It was clear to Robta that the answer to the puzzle of atomic fragments would be solved if one could actually see them. New microscopes with higher resolution had to be developed in order to determine the shape of the sub-atoms. Were they really cubes like everybody assumed? Often in the history of science the tacit assumptions of a time had turned out to be wrong. Robta even re-examined the evidence for the pentomino shape of atoms, although he did not find any ground for doubt.

As if refreshed by the shallow life of his past months, Hessin suddenly came up with an important question. Why did everybody including himself multiply the weight of the fragments by 5? Why not try other integers? When he multiplied the weight of the fragments by 9, the result was 2.0. The sub-atoms weighed 2/9 of the atom, not 1/5! What simplicity! Back to integers! Feverishly he looked for ways to divide pentominoes into nine equal parts.

Robta had noticed with relief the sudden change in Hessin. Cautiously he began to ask him about his progress, but there was no need for caution. Hessin overflowed with the desire to speak, and Robta listened well. Why should the nine parts be equal? he asked Hessin.

Hessin remembered this moment for the rest of his life. Never would he forget his sudden insight into the freedom of Robta's mind. He was right. The parts did not have to be equal as long as they were able to generate the twelve atomic pentomino shapes.

He also remembered immediately the particular nine, unequally shaped parts of equal weight which were known to be able to compose all twelve pentominoes: The pentominoes themselves! Each pentomino could be built from nine pentominoes, that were three times smaller (Fig. 28).

Looking at the particular ways in which pentominoes could be built from 'sub-pentominoes', the simplest explanation for the 2/9-fragment was the formation of a pair of an exat-shaped sub-pentomino with a corat-shaped one (Fig. 29) or an exat-shaped one with a starat-shaped sub-pentomino. If that was true, it could explain that nobody had ever succeeded to produce a fragment from douwat and parat (cf. Fig. 28).

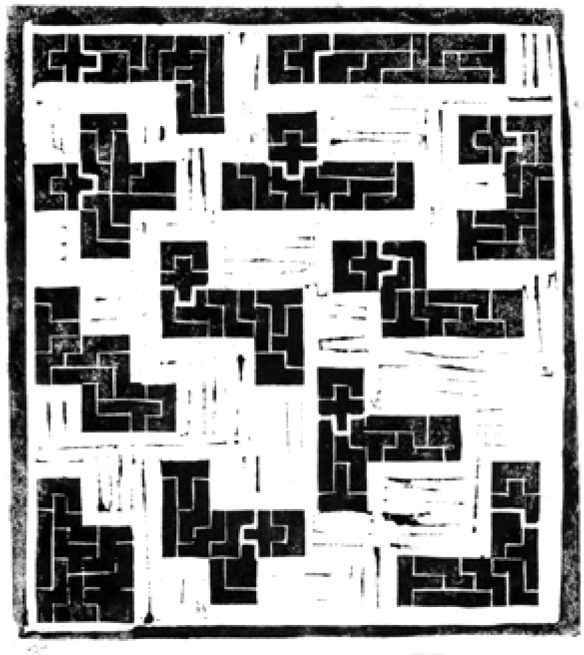


Figure 28 Hessin's discovery that the gluon-theory is wrong, and that each pentomino shaped atom consists of 9 smaller pentomino shaped sub-atoms, which consist each of 9 even smaller pentomino shaped sub-sub-atoms... and so forth forces the world of science to acknowledge its inner limits: There will never be a final explanation of the world based on pentomino shaped atoms, because pentominoes explain pentominoes explain pentominoes... without end.

The rest of the story is well-known. With improved diffraction methods based again on war-time inventions, the predicted shapes of the sub-atoms were confirmed. Hessin was right: The pentomino shaped atoms were composed of pentomino shaped sub-atoms. Were the pentomino shaped sub-atoms composed of pentomino shaped sub-sub-atoms, and so forth?

Infinity tore open. The explanation of pentomino shape was pentomino shape itself. The world would never be explained by the shape of its parts. Bekkel's dream was shattered. Science was stuck like a phonograph in a rille: Pentominoes explain pentominoes explain pentominoes...

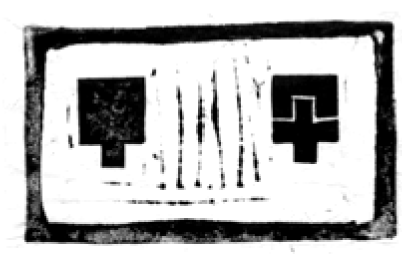


Figure 29 The U-X-fragment that can be separated from most of the atoms as discovered originally by Huller and which caused the world-wide acceptance of Menda's pentomino theory. In contrast to the original belief that its atomic weight was 1/5 = 0.2, it has actually an atomic weight of 2/9 = 0.22222... Thus retroactively it became clear that Hulle's discovery formed the erroneous basis for the proof of the correctly postulated pentomino shape of atoms.

DOUBLE TALK

Heartbreak of the prophets

The blessing of weapons and the justification of genocide, that had been the dubious privilege of religion for centuries, passed into the infantile hands of science. The demon that had seized science was no longer satisfied with new murder weapons, but wanted science to find novel ways to rationalize murder.

In the past centuries, priests had called for the death of 'pagan' enemies. Now science 'proved' the enemies to be inferior and a threat to mankind: Hiltis, the monster child, the mad ruler of the Central Range used genetic 'proofs' for the racial inferiority of the Wens to call for their mass murder. Many Wens were struck down, raped, expelled. It happened in the name of science, that had risen to its highest achievements by so many great Wen minds.

While genetics raised a fraudulent voice to support his nightmarish babbling the monster child from the Central Range set the world on fire a second time. Science's latest inventions killed unprecedented numbers of humans in fires of diabolic sophistication. The demon of science was here to stay.

Whoever escaped from the Central Range came to the city of New-Gettok in the New Province. Like the old Gettok on the Central Continent, it was a huge city of uncountable waterways and buildings that no human exploration could ever hope to exhaust. The fugitive Wens arrived poor, but with undiminished knowledge and desire for wisdom. They crouched near their few possessions and added their magic of reason to the immense complexity of New-Gettok.

Many scientists who had escaped from the inferno of the Central Range gathered in a desert summoned there by the government of the New Province. The alliance between the demon of science and the monster child of the Central Range threatened to turn the grace and magic and splendor and wealth of reason that had once been science, to unprecedented destruction. The scientists agreed to tear the last veil from the demon's face:

Atoms could be shattered into sub-pentominoes while unleashing energies that hitherto had been the privileged possession of the stars. The scientists made it happen in the desert. On one irrevocable day the first atomic bomb exploded, and the most hideous face of the demon rose with fire and dust into the sky, gigantic enough as to darken the sun.

Those who had seen the demon lowered their gaze. There was no human category of punishment or reward for tearing the veil from a demon's face. There was only heartbreak.

The tricks of creativity

Fraud? In science? The first time it happened, everybody dismissed it as a rumor planted by the anti-science groups Ridiculous! Why would anybody fabricate data? The whole purpose of science was to report facts of nature that anybody with the right equipment could verify and eventually put to practical use. Nobody could do that with fabricated reports.

It was no rumor. Suller had fabricated data for years, until five years later an assistant was denied a promotion and started to talk. What had happened to science?

Most scientists no longer searched for fundamental truths, but were involved in jealous battles over priorities and positions. Strategic manoeuvres occupied their minds. Retirement payments moved into the focus of young scientists, who became increasingly insecure about their future.

How easy it had been for people like Menda! They needed hardly more than a chair and a gas-burner. In their time, everything was yet to be discovered. Naturally, the first discoveries had been the least expensive ones. The others just could not be made, because they required money. Now the easy ones had all been discovered and the time had come to try the more expensive ones. Therefore, you had to get money from the government, from companies, from municipalities. How? By their rules of justification, feasibility proofs and competition between bidders.

The pressure on scientists to perform, proof, document, predict, and anticipate the political moves of competitors rose to almost unbearable levels. Yet, science remained stubborn like a mule. It resisted predictability and peer judgement as before. Nobody could say whether the experiment would turn up the answer. Nobody could assess the significance of a discovery right away. What could a young scientist do, if everybody who gave money insisted on predictability?

The obvious answer was to become famous and become a sure bet for the investors. Therefore, one had to strive for notoriety. Newspaper reports about one's work became an important weapon. Medals, awards, even controversies became nightmares of jealousy if they happened to the colleague next door, and they became the ultimate fulfillment if they happened to oneself. After all, what greater success is there, than what soothes one's fears?

Still, such success did not remove a single fear, but kindled new ones. There was little consolation in having won the National Award some five years before a competitor, if he or she won it later and was rapidly closing in on one's strategic position. It was necessary to stay on top, but too many were pressing onto the small platform on top of the ivory tower.

Of course, there was no fraud in those circles. There was too much limelight. Only irrelevant people could afford to cheat. Yet, theft was acceptable. It was easy to publish the data and ideas of less powerful scientists. Theft was almost impossible for the victim to prove. After all, access to the publication media presented no problem for famous scientists. Why then did the less famous scientists not hide their ideas and discoveries until they could publish them first?

If you were on top, the young talents had no choice but to be open with you. As an editor of a journal you had to read their papers before you could accept them for publication. If they needed letters of recommendation, they had to explain the details of their work to you. Or assume that you decided about the invitations for the Ro'alam meetings. If these people refused to describe their results to you, how could you invite them?

They were easy sheep to shear. The real problem were your own peers, since they were equally powerful and could steal from the same sources. Successful scientists like business people began to develop health problems already in their mid lives. One more reason to be tough, to think ahead, to plan early for retirement.

The art of survival taught not only the power of books, but the power of trade and commerce as well. Now the spirit of markets began to dominate science. Under pressure to finance the growing cost of science, scientists began to offer products of their work for sale. Their ideas could make the difference between success and bankruptcy for some commercial companies. Consequently, scientists were courted by industry, and their subsequent rise to financial power added another dimension to the competitive battle among them. Of course, they were also grossly ignorant about practical matters of commerce. Of course, once bled for their ideas, these scientists were tossed away by the factories. Out of touch with science for the time of their commercial involvement, and out of new ideas, yet greedy for more wealth, they fell victim to new kind of intellectual poverty, that hurt science even more. However, by the eternal rules of human folly, their successors never believed that it could happen to them as well. The cycle continued.

The public perceived the developments differently, though. Regardless of the increasing number of burnt out scientific minds, the public enjoyed spectacular advances in the methods and instruments of daily life and health, and a fast rising standard of life spread among the population of the world. No wonder, the public demanded more and more technology from science. No wonder, the public celebrated the scientists had turned into successful engineers. No wonder, scientists delighted in new sources of fame. No wonder, the cycle accelerated.

To be sure, there were other voices in the public, too. Not everybody caught up with the progress of science. Not everybody, whose understanding fell behind, shrugged it away. Many felt threatened, and took aggressive action. By then science had become quite vulnerable, bleeding from internal wounds.

Vision of balance

Kim-Atai was the first Karata to become director of Ro'alam University. Already as a young man he had sought a synthesis between the new concepts of science and the old wisdom of the Karatas. Both teachings seemed powerful, yet opposed to each other. A major obstacle for his attempts of a synthesis was the explicit condemnation of scientific efforts by one of the early emperors, who had put a halt to his people's own early scientific successes.

The core of Karata teaching was the logic of complements. Over millennia his ancestors had studied the expressions of polarity of the world, and learned the mystery of the balance between the opposing forces that humans called male and female, good and evil, dark and bright, weak and strong, or creative and destructive. Their symbol of the balance was a circle divided by two other circles into two identical drop-shaped halves that circled around each other. One half was shaded black, the other remained white, symbolizing the belief that good and evil are opposites of equal size, which supplement each other in order to yield the perfection of a whole, nevertheless. Kim-Atai had always been moved by the simplicity and depth of this symbol.

Forced by his study of chemistry to think about pentominoes, he tried to form the symbol out them. He found, indeed, that the twelve pentomino shapes lent themselves to forming an almost circular shape that was divided into two halves quite similar to the old symbol (Figure 30).

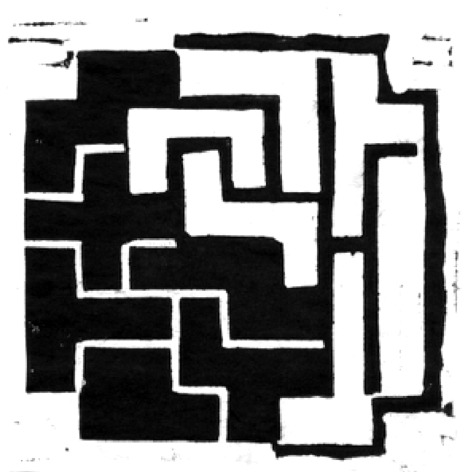


Figure 30 Kim-Atai's discovery that the twelve pentomino shapes form the ancient Yin-Yang symbol sets his mind in motion about other aspects of complementarity hidden in pentomino shapes. Eventually he discovers the self-complementing structure of CNM, the genetic molecule (cf. Figure 32).

He was mystified by the fact, that the twelve pentominoes had the ability to express this image of complementarity. Should not other structures that were composed of pentominoes express complementarity as well? Since everything was built from pentomino shaped atoms, he had searched for other expressions of complementarity among the creations of nature. And he found a most significant one that was to turn the history of science into its last and most momentous fulfillment.

Letters from eons past

When Kim-Atai began his work, it had been known for quite some time that every protein was a rectangular plate. One side had a length of 6, the other of 10 sub-cube units. Each was a perfect fit of all twelve atoms. In other words each protein was the solution of a mathematical problem, namely the problem of fitting the twelve different pentominoes into a 6 x 10 rectangle. Nature had found solutions for the problem and had passed them on for millions of years in the form of proteins that were synthesized in huge numbers by tiny cells. But how?

At first biologists seemed little concerned with the problem, because they thought that the twelve pentomino shaped atoms would simply fall in place after their thermal movements had given them enough trial and error chances. If cells merely provided the 6x10 frame, then thermal chaos should rearrange the pentomino shaped atoms until they happened to fit the frame.

Of course, the explanation had to be wrong. In the first place, the postulated mechanism had to guarantee that exactly one of each pentomino would fall inside the frame, but not two or three of the same kind. What could prevent several zalat atoms from settling within the frame? Theoretically, there were plenty of ways to fit pentominoes into the 6 x 10 frame with one pentomino shape missing while using two of another kind. None of these would be a protein. How could nature prevent their formation in this supposedly blind trial-and-error scheme?

Furthermore, the cells did not contain arbitrary proteins. Liver cells had several proteins that were different from brain cell proteins. How could the trial-and-error method provide the selectivity and specificity?

Most devastating, however, for the trial-and-error hypothesis was an estimate of the required time. There were about 1,000,000,000,000,000,000,000,000,000,000,000 possible configurations to try! The number of successful configurations, that is the number of perfect fittings were estimated to be between 2,000 and 10,000. In other words, the chances of finding one by accident were less than 1 in 100,000,000,000,000,000,000,000,000,000. At these odds even an incredibly fast trial-and-error method, that could try out a billion configurations of the twelve pentomino shapes every second would still take more than a billion billion years before a solution could happen by chance! No, that was definitely not the method that nature used.

As a next refinement of the trial-and-error hypothesis, Hanser combined it with the concepts of chemical affinities, however with little success. Like its predecessors his theory could not explain how nature prevented the incorporation of multiple atoms of the same kind into a protein.

For a while Goldin's concept of the 'proto-compound' attracted attention. According to his theory, 'proto' was a material that consisted of a linear chain of all twelve elements. Upon protein formation, one such proto-molecule folded itself into the 6x10 frame like a snake into a box, thus giving rise to a protein molecule. After an initial success of predicting the existence of certain byproducts of protein synthesis, Goldin's theory soon fell into oblivion, because nobody could find proto-molecules inside cells or anywhere else.

The first breakthrough came with Herrish's recognition that the problem of protein synthesis was actually a question of genetics: Be it the shape of a wing, the color of eyes, or a protein structures, it was all the same problem of how nature passed on building instructions from parents to offspring. In a remarkable series of experiments, Herrish and her students traced the problem of heritability to a substance in the cellular nucleus, that had been discovered actually thirty years earlier and had been called 'cellular nucleatic mucus' or 'CNM'. Still, the mystery of protein synthesis needed one more idea before it could gather momentum.

The idea came easily to Kim-Atai. He turned Goldin's concept around. Even if proteins were not made from a linear chain of the twelve different atoms, there was always a way to read a given protein as a linear sequence of the twelve atoms with their particular orientations.

Exat could exist in only one orientation, corat in four. There were four orientations also for teat, vat, douwat, zalat, as well as eight for lavat, starat, at, parat, and turat. Irat could be placed in the 6 x 10 frame in only two possible orientations. All together, that made 1 + 5x4 + 5x8 + 2 = 63 'letters', namely the different atoms in their different orientations. For nature to pass on the information of protein configuration, meant to write down a 'word' made of twelve of these 63 letters in a linear sequence, such that it would 'encode' the protein structure. One needed also a 'stop' - code, in order to mark the end of the last and the beginning of the next such 'word'. All in all, one needed 64 codes. Thus Kim-Atai had turned an apparently chemical problem into one of writing words.

The last stage

The first reaction of scientists to unknown phenomena is usually the assumption that they result from random chance. As knowledge increases and natural laws are discovered, they consider the events as automatic, mindless expressions of these laws. Only in the last stages of the maturation of a field certain phenomena are considered as expressions of intelligence in nature.

The understanding of CNM followed this sequence. After Herrish had shown it to be the carrier of heredity, scientists developed first the chaotic model. The analysis of CNM revealed that it was composed of only five smaller kinds of molecules. One was exacorat, the other four were named Adin, Thon, Gon, and Cin, abbreviated as A, T, G, and C. Their structure was unravelled and found to be closely related to each other (Fig. 31). It also became clear that in the native CNM material the four were bound to exacorat. Therefore, CNM was interpreted as a random polymer of the four substances together with exacorat, a chaotic polymer, of course, a polymer with a random sequence, 'exacorat + AATTCTGGCATT... '

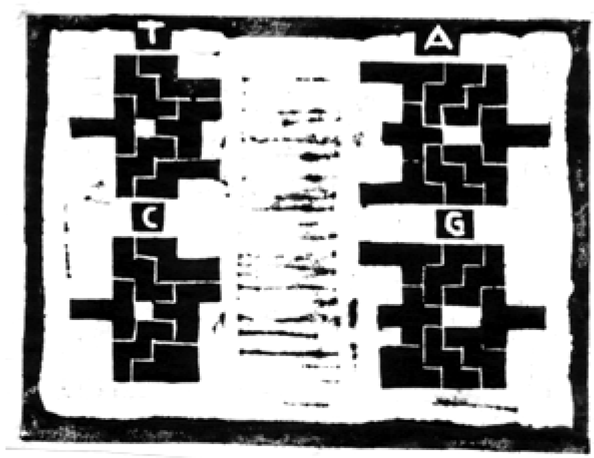


Figure 31: The molecular structures of the four letters of the genetic alphabet.

Kim-Atai had just begun his work when the 'random heteropolymer-model' swept the most recent editions of textbooks, and resounded from countless lecture halls. Everybody agreed that Herrish was wrong about the significance of CNM for heredity. It was merely an inert framework, a scaffold that supported the - still elusive - master material of heredity, like a kind of wrapping material.

It was not very flattering for Kim-Atai to be told that he was studying the filler substance of heredity, but as a rule, he did not believe majorities in science, anyway. Thus he faced alone the task to take the next two steps in the development of scientific understanding that was bound to follow the concepts of random mechanisms: the concept of automatic mechanisms, and finally the concepts of intelligent mechanisms.

Images of self

Menda had unravelled nature's intricate esthetics, Gennar had discovered nature's profound pleasure with mathematics. With Wardon's insights came the understanding of nature's obsession with catastrophe. Hessin had proven the paradoxical and infinite core of nature's clarity. Now it was Kim-Atai's turn to demonstrate to the world the brilliance and depth of nature's intelligence as it was expressed in the structure of CNM.

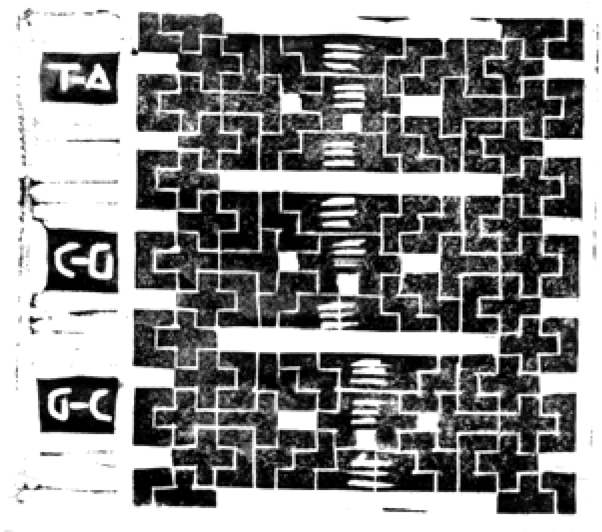


Figure 32 Molecular structure of CNM as discovered by Kim-Atai. It is a self-complementing double track of exacorat to which the genetic letter molecules are attached at regular intervals. The two complementary track can pair by means of three resonance bonds that form between the open ends of the letter molecules. Based on this discovery biology grows rapidly to become the dominant science. People learn to manipulate CNM. Eventually, Hanebb abuses the technique as he inserts extra copies of human α-endorphin genes into a virus and infects the members of a hated sect with it. Unwittingly, he triggers a new leap of the evolution of the human brain.

His discovery sent a whole generation of biologists into a frenzy of new and ever more exciting discoveries. one merely had to look at the structure of CNM, in order to read from it the details of cellular protein encoding and synthesis. The many elegant experiments that confirmed what the structure of CNM had suggested, set future standards for biology and science at large. It was all the result of Kim-Atai's 'complementary pairing principle.

What Kim-Atai had discovered was the complementary pairing of Adin with Thon and Gon with Cin by forming three resonance bonds. The structure of CNM was a pair of exacorat tracks of great length. Both tracks carried one of the four molecules namely Thon, Adin, Gon or Cin at every fifth exat atom. A particular sequence ACCTAGCGGT... was arbitrary on one track, but then completely determined on the second, because due to the resonance pairing, only an Adin could be opposite to a Thon, and a Gon could only be opposite to a Cin (Figure 32). Thus the molecule was its own complementary copy which offered an elegant way for its self-duplication. What brilliant intelligence of nature! The language of her will over eons was a confirmation of the ancient Karata knowledge of universal complementarity!

An encoded protein was the sequence of 12 out of 63 possible codons, followed by a stop-codon. How does one encode on CNM a sequence of 64 different objects using the four 'letters' A, T, C, and G? Simple! Group them in three, because there are 4x4x4 = 64 combinations. For example the triplet AAG coded for exat, ATC for irat on one orientation and ACC for irat in the other, and so forth. Thus a sequence ATCAAG... could be chopped into a sequence of triplets ATC-AAG-... which coded for exat-irat(l)-...

Thus Kim-Atai took the next two steps in the general scheme of understanding at once: He replaced the 'chaotic' model of CNM, and showed that CNM duplicated 'automatically', while its encoded messages demonstrated the action of 'intelligence' in nature. Of course, the discovery brought him the National Award, and subsequently, the first Karata directorship in the history of Ro'alam University.

With the structure of CNM as basis, a wealth of new discoveries followed and biology began to dominate among the other sciences. What could be more fascinating for a scientist than to join in the world-wide effort to decipher CNM, the ultimate text, in which nature had written notes to herself describing the origin and the workings of life? The optimism among scientists was exuberant.

THE FOURTH BRAIN

A turning point.

New Year's eve was bad. The turn of a new century was traumatic. The onset of a new millennium spelled catastrophe. Police statistics all over the world showed bursts of violence and suicides around New Year, and the two turns of a century for which records existed showed major turmoil in the population. The last turn of a millennium fell into the so-called dark ages, that had left no reliable records, but the legends abounded. Mass insanity, mass murder, population migrations, and the birth and death of many extraordinary people were told in the stories of this remarkable date. Of course, nobody was sure, but legends never arise without a cause.

Lao was aware that the turn of the present millennium was only thirty years away. Were people this time more rational, more educated? Did they communicate better with each other? These questions decided whether the last evening of the present millennium would become the worlds greatest celebration or unprecedented slaughter.

It seemed to some that the new millennium would become a time of utopian achievements of science. Men would travel across the galaxy. Insights would reach the deepest recesses of matter, mind and universe. Lao, though, had his doubts. He remembered too well the order of the ancient emperor of his people to stop any further development of science, many millennia ago. In this century, which was the last of the present millennium, science had already shown a demonic face. It had slaughtered millions more people than it had rescued from poverty and disease. Science had extinguished more animal species and more human cultures than any event of recorded history before.

Compared to the optimistic atmosphere at the beginning of the century the present atmosphere seemed stale, humid, oppressive. The voices praising progress were too loud and frequent as if they tried to silence others. Something was gathering momentum, and Lao feared it would not be good.

Opposition to science was not new, but the number of religious sects who denounced science and preached the return to a life in wilderness was rising too fast in Lao's opinion. Unfortunately, science had turned progress already twice into destruction. First the holocaust of the atomic weapons, then the destruction of living space through its pollution by chemicals of science. Now a third threat of science was leading to a confrontation between scientists and anti-science religious groups.

Biologists had learned to modify genes. They promised to cure diseases, to produce rare medicinal substances, to alter susceptibilities of crop plants and breeding stock to blights and pests. They projected a time where the oceans would feed the world with genetically modified algae, and where damaged human organs would be regrown artificially. The world seemed ready to accelerate evolution without any Wardon-catastrophes, and improve the hereditary traits of plants, animals, and even humans.

Was it ready? No matter how colorful scientists painted the benefits of the new methods, an ever larger number of protesting people maintained, that mankind was not ready to meddle with the ultimate scriptures of life, and would never be ready for a sacrilege of such magnitude. One could no longer ignore the voices.

Governments designed safety regulations which controlled and restricted all scientific work with genetic alterations. The regulations were quite stringent, and intended to prevent the accidental escape of a genetically altered organism that could potentially damage all life on the planet. The regulations almost abolished experimentation altogether.

The measure did not pacify the ever rising numbers of anti-science religious sects. They preached that science had first taught mankind the devil's powers, and now it tempted mankind with God's powers as well. After the destructive powers of atomic weapons were given to all governments by scientists, the power of creating new life was their next goal. Today you modify a gene, tomorrow you build a new human! In villages and towns flames began to rise from stakes of books of science.

Reason in agony

The use of hallucinatory drugs was no longer a hushed-up secret of wealthy families. Youths everywhere fell victim to the quick relief from their fears. Had not biology taught that all of life was a matter of chemicals? If there was a chemical for everything, why not one for the peace of mind?

Indeed, there was a chemical for the peace of mind produced by the brain of humans and animals. Wounded soldiers, athletes at the verge of physical collapse, people who had rescued others while disregarding their own injuries, all these and others had experienced the power of the mind to suppress fear and pain. The ability to retain command in the face of death had always been regarded as a mystical power of the mind. Now, biologists had found a chemical explanation. Under extreme stress the brain produced narcotics from special genes, and released them into the blood stream, thus drugging the individual. Yet, oddly, they had never caused addiction in people. In analogy to the most addictive drug 'morphine', the endogenous ones were called 'endogenous morphines' or briefly, 'endorphins'.

Soon, the most frequent endorphin, the so-called α-endorphin became the focus of several competing groups of biologists and brain researchers who tried to unravel its mechanism of action. The new methods of gene manipulation were most welcome by these groups because the brain produced the substance in too small amounts for effective research. Eventually, a group at the Brain Institute of the Central Range was able to isolate the gene for human α-endorphin and to introduced it into a laboratory strain of the human gut bacterium, F. inerdii.

Rapidly, the mechanism of drug action unfolded after sufficient amounts of α-endorphin could be synthesized, labelled and injected into animals under various situations of stress, feeding and exercise. The reaction of nerve terminals could be studied in detail, and the receptor compounds for the endorphin were isolated and characterized. Soon scientists were trying to manipulate the genes that coded for the receptors. Obviously, if one could change the receptors in such a way that they continued to accept endorphins, but rejected the addictive morphines, a most successful cure for drug addiction seemed just around the corner.

In the meantime, however, drug addiction took growing tolls of human lives. Rather than joining the battle against drugs, the anti-science sects used drugs among their followership to let them experience happiness without the dangers of reason and science. If the attacks of the sects on science had been irrational all along, now they acquired aspects of insanity and drug-induced nightmares. Recently, five members of the Navel-sect had stormed a laboratory at nightfall and ritually killed three scientists and the night watchman. The five were captured and sentenced to imprisonment for life. However, the Navels and other sects celebrated them as heros and martyrs.

The sects realized that they needed a system of counter-teachings. Anti-science was to be formulated and taught. Where should they begin? Not all of science could easily be discarded. Many of its ideas had grown roots in human imagination, that would not be easily eradicated. For instance, the system of twelve pentomino shaped elements, each consisting of nine pentomino shaped sub-atoms had struck a deep chord in human minds, that the sects could not fight. Therefore, they claimed it as their own insight.

They preached, how they had learned the truth from the stars. Scientists had merely acquired ancient spiritual knowledge and declared it as experimental truth. How could they have hoped to fool us? Visible to everybody's eyes since the dawn of humanity there are twelve constellation in the sky, shaped like the twelve pentominoes (Figure 33), are they not? Thus the Gods themselves wrote with the ink of stars onto the sky the shapes of the elements from which the stars were formed.

How poorly had the scientists concealed their plagiarism when they 'discovered' that the twelve pentominoes were formed from nine sub-elements! Are there not nine planets weaving enigmatic paths between the twelve constellations, which foretell our fates? We shall read for you the paths and the shapes and the future.

The musical octave consists of twelve half-tones, one for each pentomino in the sky. Thus, music is the language of the heavens. Do you see why music reaches the core of the human soul? It all resonates in eternal harmony. The minds of the great composers had arranged the twelve shapes along the eternal laws of creation. How shallow is science compared to music! How shallow is music compared to the divine melodies of the heavens with which we shall elate your soul!

We teach you the truth of triplication. As nine pentominoes unite in a unique and harmonious way to form one large pentomino, they recreate themselves three times larger. Three times! Listen! Three times, not twice as large, not twelve times as large. What is three, you ask? There is the void and the thing and the anti-thing. United they are the eternal void, separated they are the world. Hear me teach, hear me sing of the sacred Trinity! Listen, oh listen with your heart! Let not reason disturb the sacred song!

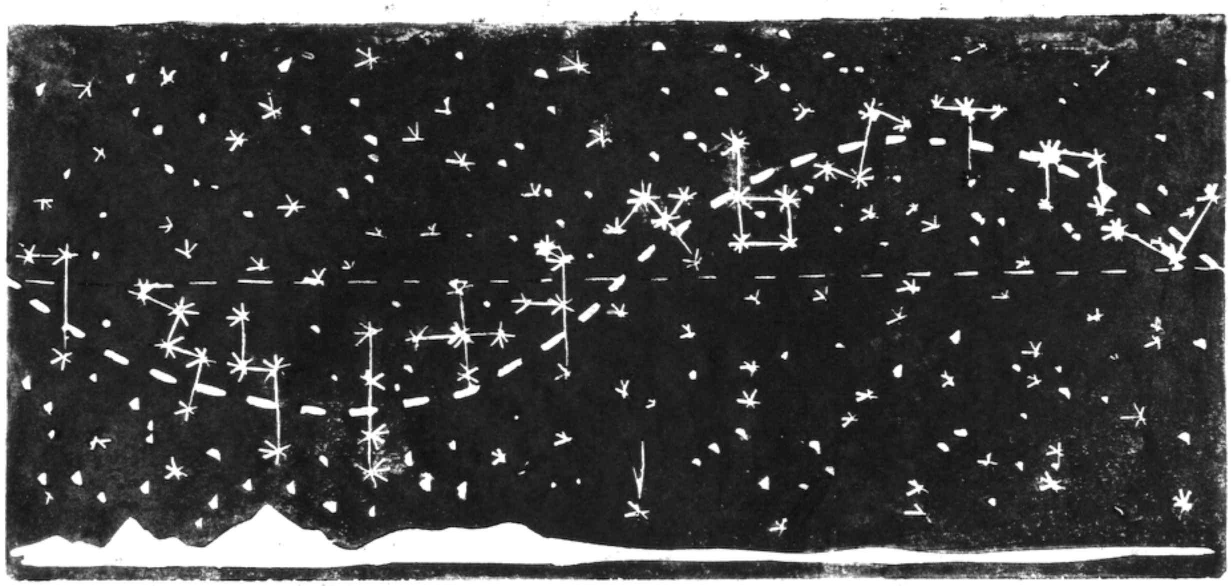


Figure 33 Redrawing of the constellations to form pentomino shapes as science-hostile sects claim that pentominoes were not discovered by scientists but had been written on the sky for us since the dawn of time. They taught how two, the thing and the anti-thing made five, namely fire, water, wood, earth, and metal. They created twelve atomic shapes, twelve constellations, twelve tones on the musical scale, which together created the world.

Science dies to the drum-beat of the sects at the moment when it has served its purpose. As child of the third and youngest human brain compartment, it becomes clear to Lao that science had done nothing but to prepare a violent transition to the formation of a fourth human brain.

The three created the five. As the Karatas had taught since many millennia, they formed the five spirits, namely fire, earth, metal, water and wood. Each of the five strengthens one and weakens the others.

Thus, the five unite in twelve, and only twelve ways. Each of the twelve sacred pentomino shapes combine fire, earth, metal, water and wood in unique and fundamental way. They created all there is. Thus arose the twelve constellations in the sky and the wind's twelve directions. The twelveness of music, the twelve meridians of our bodies, the twelve organs and the twelve pulses of our hearts resonate the eternal harmony. Listen well! No music is greater than the harmony of the heavens. The greatest musical minds sing of their beauty. They sing eternity. Fight reason! Kill reason! Listen to us! We shall free you from the evil of reason!

The three brains

The sects closed in on science. After convincing a large followership that reason was synonymous with evil, after announcing that worse threats than atomic weapons would follow in the wake of more scientific progress, they moved in for the kill. With unfailing instinct they focussed on science's weakest point, namely Wardon's theory of evolution and what had become of it.

Science's strength was experimentation, but there was no experimentation with the planet's distant past. Scientists could do little more than combine by means of reason the serendipitous unearthed fossils with their knowledge of the planet's present state. Yet, at the present time reason was banned. The sects attacked and watched the theory of evolution tremble, while its defenders desperately tried to resort to reason, although they were forced to admit that science had to be based on experimentally reproducible facts. Science had always failed when arguments had to replace experimentation. Human minds were too limited to outguess nature's ingenuity. Only in retrospect could they hope to follow her thoughts.

Well, if that was so, how could you dare to reconstruct the origin of life? You did not even understand how present day life worked, did you? Fools, indeed. Dangerously conceited fools, who should be taught modesty and self - criticism. Forcefully, if necessary.

Lao struggled with Wardon's concept of evolution in his own way. He sought the answer in the brain of the organisms. Maybe the evolutionists were right about the mechanisms which operated during the earliest times of life on the planet, but later the changes of organism were no longer left to accident alone. Was it possible that the brain directed evolution? Lao decided to study neuroscience in order answer the question. However, he soon found a devastating fact for his theory: The brain itself had evolved in leaps, suggesting that Wardon-catastrophes had been involved.

His teacher in neuroscience was Mac-Lin, an unusual personality, fiercely independent in her thinking, radical in her dismissal of common prejudices. When he told her about his idea of a brain-controlled mechanism of evolution, she accepted him as a student.

On his first lesson she took him to the dissection laboratories of the medical students. While she sawed open a skull, Lao watched with all the horrors of a novice the cold-blooded treatment of cadavers by professionals like Mac-Lin.

Finally she took out the brain and put it in front of him on the metallic table top. He saw the two large hemispheres and a few small lobes on the bottom that ending in a piece of the spinal cord that she had left on.

"This brain is actually three brains," she explained. "The two large hemispheres are the mammalian brain. Different mammals develop it to different sizes. Only humans have this enormous relative size that you see here. This layer on top of the brain makes it so large. It is the genuinely human brain. In contrast, we share the layer underneath and these lobes with other mammals."

She turned the brain upside down and pointed to a number of curiously shaped extrusions.

"In this sense, the second layer forms another brain. Historically speaking it is the brain of the early mammals."

Then she pointed to a pear-shaped part in the middle that extended into the spinal cord.

"That leads to the innermost core underneath the mammalian brain, which is a third separate brain." Mac-Lin explained. "We share it with reptiles and fish."

Lao tried to understand. "How naive of me. I had always thought that there is only one brain." he said.

"No, these three are quite distinct in morphology and function in each of us." answered Mac-Lin. "The development of the triple-layered brain is very interesting." she continued. "It leaped from one to one plus the next: from the reptile brain to the combination of reptile brain and mammalian brain, and from there to the triplet of reptile-brain, mammalian brain and human brain. We became human when the third brain evolved."

Lao was silent for a while and stared at the brownish mass in front of him while Mac-Lin continued.

"The human brain, the third brain is the youngest and the most helpless of all. Its specialty, namely the abstract thought is easily ignored by the other two. Vision and odors, the specialty of the mammalian brain are more powerful. The most powerful and the oldest of the three brains, however, is the reptile brain. Its specialty are emotion, fear, and sexuality. Why do you think the sects are so successful?"

Revenge of a refugee

Lao fought his way through the traffic to the airport as he expected his old friend Hanebb. It was no happy occasion, though. Hanebb was a refugee from the Central Range, where the Nave 1-sect had taken over University City, and had established a terrifying regime.

They did not even act illegally. The laws of the country specified the legal right of every community to issue their own laws of local government, as long as they were compatible with the constitution. After the Navels had won Pellaka's last election by a landslide, they began to rewrite the local laws, including the laws of University City.

The new laws prohibited the practice of science of any kind with the exception of health science. Within a month the university was closed. Only hospitals remained open. Some scientists succeeded to leave Pellaka, but many had no place to go. Hanebb had written a desperate letter to Lao, asking for a position at Ro'alam University. Any position would do, anything at all. Without an offer from another university the authorities of Pellaka refused to issue a permit to leave the city. That was another law. The Navels explained it as an assurance that no citizen of Pellaka, the future Holy City, was to suffer from hunger or thirst away from home.

In the time since the arrival of Hanebb's letter the situation had deteriorated even more. In a public ritual, the university of Pellaka had been exorcised. The act had included the burning of several buildings, and the founding of a temple of the Navel sect in their place. Afterwards, a string of trials began. Hundreds of scientists were seized and accused of conspiracy with the devil. Their trials took place on the main campus square. In front of a huge crowd of spectators the public attorney read the accusation, and demanded a plea of innocence or guilt. Afterwards a long line of witnesses testified to the satanic activities of the defendant, citing publications and textbooks as proof. The verdict was invariably expulsion or imprisonment. Regardless of sentence, however, each defendant had to be submitted to an exorcism that lasted one month and had already claimed three lives.

Recently, the public trials had become even more violent. Blood thirst rose. The public attorney had begun to demand the capital punishment for scientists. Fortunately, the laws of the country required a state trial for capital cases, and the Navels knew that they would not succeed in state court.

Women and men alike were charged with sorcery. Fortunately, Hanebb had so far escaped the worst persecution, because Karatas had been less persecuted than scientists of other races. He suspected that the reason was the influence of some powerful Karata members among the Navels. But, of course, he knew that it was only a matter of time until the new government of Pellaka expanded its witch-hunts to all scientists irrespective of race.

Nevertheless, his race gave Hanebb the edge for escape. After an adventurous journey by foot and car, he arrived in Paka. As Paka was overcrowded with refugees, it took him three weeks to get a seat on a flight to Ro'alam, but eventually, he saw Paka receding below him in the distance. He sighed with relief when the plane crossed the coast-line and headed across the sea toward the Northern Province.

The plane ride was unusual. The pilot made complex manoeuvres and seemed to turn the plane much steeper than usual. In mid flight the plane entered an area of turbulence and dived so abruptly that everybody gasped. Yet, the expectation of freedom after weeks of fear for life, let Hanebb and many other passengers forget the danger and they laughed at the roller-coaster ride.

Lao watched the plane's approach from the observation deck. After touch-down he would still have to wait for an hour until the passengers had passed through customs and health inspection. There would be sufficient time to walk down from the observation deck to the arrivals area. All of a sudden the people around him screamed in terror. Lao looked up and saw the plane turn its wings vertical as it approached the runway. The wings rotated further. Soon the plane was flying on its back. While everybody froze in terror, the plane completed the roll, restored its normal flying position, and sat down on the runway as if nothing had ever happened.

In the grip of a nightmare

The voice of the public attorney almost snapped. Her face red, her hands shaking in anger, she screamed at Hanebb.

"You will never be able to justify your act. If I ever regret that our laws prohibit the death penalty, it is because of you and I hope that the jury feels the same way."

"Your Honor", she turned to the judge, "the state has produced sufficient testimony for one of the most hideous crimes against humanity. The defendant has confessed to this crime. Willfully and for the sake of personal revenge he has seriously damaged the health of the entire population of the Planet.

As we have demonstrated, the defendant Hanebb, citizen of the Central Range and refugee to the Northern Province inoculated intentionally and in full command of his mind numerous citizens of his home country with a tampered strain of common cold virus. He did it as an act of revenge against the local policies of the so-called Navel-sect. The virus was modified by himself to contain the gene for the human α-endorphin. As a result, ever growing numbers of people, infected by the virus mass-produced α-endorphin. The defendant was fully aware of the possibility of permanent genetic change following infection with the virus. In fact, he counted on it, when he inoculated his first victims."

Lao sat in the audience. There was nothing he could do for his friend. He understood his reasons, but he did not understand how he had overcome the moral barriers between the intent and the act. Only a man driven to ultimate despair was capable of this crime against everything for which science stood.

Right now the public attorney was speaking of this very first incident of α-endorphin overdose.

"... it does not matter, that the defendant himself was on the plane. Many innocent people would have been killed if the infected, and thus drugged and incapacitated pilot had missed the runway after his side-roll. We accept the defendant claim that he did not know of the pilot's condition. We reject, however, his contention that he would have warned the passengers. Rather, we are convinced that he would not have jeopardized his escape by attracting attention to himself. We think that he would have swapped seats with a passenger on the next flight, a simple thing to do, considering the long waiting-lists.

We also submit that the defendant swift confession after the medical examination of the pilot does not speak in his favor. What else could he have done? Even a mediocre detective would have been able to identify the originator of the peculiar virus. After all, modern methods to determine the exact sequence of a gene would have taken no more than two weeks to identify the particular gene-vector for α-endorphin as the same that the defendant had isolated and published several years ago. There were peculiar sequences attached to it that could identify unambiguously the laboratory, and thus the scientist in charge. Other suspected scientists would have been vindicated very quickly, I am sure. In short, the defendant confession and collaboration with the authorities, should not be considered as mitigating circumstances."

That was not fair, thought Lao. Hanebb had done much more than confessed and collaborated, once he had realized the full extent of the consequences of his action. He remembered the agonizing days and nights in the laboratory, when he and Hanebb were feverishly seeking a genetic property of the virus that could be exploited to develop a specific antidote. They had sequenced several mutants of the entire virus, hoping for a suitable epitope, that was coded by the virus and could be used for immunization. Yet, it was all in vain. The virus, like other cold viruses mutated its genes faster than they could detect any peculiarities. Night after night and no sleep, while Hanebb was at the verge of suicide. Yet, he knew, that he had to face his punishment. Suicide was too easy.

What folly! What Hanebb had sought to defend against the sects was destroyed by his very action. Through the narcotic action of the virus he had caused the destruction of more scientific thought in more minds and for longer times than the Navels could have ever hoped to accomplish.

The public attorney was in the middle of describing the consequences of Hanebb's crime.

"... Traffic has essentially come to a stand-still in many cities and on international traffic routes. Too many freak accidents caused by people under severe α-endorphin attacks have produces an atmosphere of unpredictability and fear. Military discipline is collapsing under the impact of erratic actions of soldiers who disobey orders under the influence of the endogenous drug, or who may handle most dangerous weapons in irresponsible ways, including atomic weapons.

In addition to the immediate danger of incorrectly handled weapons, such soldiers also leave their country wide open for attack from other countries. Hospitals had to dismiss physicians who refused to attend to emergency victims during a drug attack, and preferred to do something ludicrous, instead. Three accident victims in this very town died because a physician under the influence of a α-endorphin could not be brought to his senses for one whole hour. Only a few minutes ago, we witnessed here in this very court-room the bailiff collapsed under an obvious drug attack.

The financial burden on the countries is enormous. So far there is no cure for the victims. After infection of the virus, they usually lose their jobs, thus creating an ever growing burden on the unemployment funds. In addition, many of them had to be hospitalized at government's expense. But who wants to measure the pain and agony of the victims in monetary terms?

A new and ever more frightening development is the large number of tumors developed by the victims. These tumors occur within months after some of their body cells have become transformed by the virus. Today, only two years after the airport incident, there are sixty such tumor cases in the central hospital in Ro'alam, and the number is growing. Most terrifying, however, are the cases of prenatal infection of babies by their mothers. Some of these children develop tumors as early as one month after birth. They usually die within the first weeks of their lives."

Lao agreed. This was the most terrifying aspect. It seemed to be only a matter of time until the virus had stopped all human proliferation by drug-induced sterility of the parents, or by infant death through early tumors. Hanebb and he had seen them. They had performed autopsy after autopsy in order to understand the origin of these strange brain tumors, without obtaining even a clue of the mechanism of tumorigenesis. And what horrifying sights! Babies with huge masses of brain tissue pushing through the still open fontanelles. The dead eyes of these babies must be forever before Hanebb. So far not one of these babies had survived. Thank God, he thought. Thank God!

"... As I said before, in the case of this defendant, I regret that the death penalty has been abolished. The State and the People demand for the defendant the highest punishment, imprisonment for life." The public attorney was finished.

Crucifixion

Hanebb sat on the stone floor. The only light which entered the cell fell in from underneath the door. Amidst his silent brooding he drew deep, trembling breaths when he tried to control his upwelling panic. In a few hours he would be executed.

After their impudent crime of kidnapping him in open daylight from the high security prison in Ro'alam the Navels had brought him to Pellaka for their own trial. Hanebb could not believe that they were powerful enough to detain him despite the many applications for extradition by the public attorney's office in Ro'alam. Yet, they had proceeded with the trial and sentenced him to death.

The trial had been a travesty. In the absence of any written laws, the high priest of the Navals, Cassanka, sought to find justice by revelation. His endless monologues, interrupted only by monotonous prayers were echoed by the muffled sound of the masses praying along with him. In the end he had simply screamed out loud, turned his eyes inward and dropped to the floor. He lay there for several minutes while the masses murmured a litany that Hanebb could not understand. Finally, Cassanka rose, raised his arm high up with the pointer stretched out and slowly lowered the arm in the direction of Hanebb. When his finger pointed at Hanebb, he hissed only one word: "Death." With a theatrical gesture he cast his robe around himself and left the court.

Until last evening, Hanebb had refused to believe his fate. There were still laws! He could not be tried twice, and certainly not in this absurd way. But, after the verdict his cell remained closed until last night, when it suddenly opened Cassanka came in surrounded by priests and guards.

He stared at him with burning eyes whose pupils seemed the size of pinholes.

"You shall redeem your crime tomorrow before daybreak." he said, turned and left the cell. Before Hanebb could understand the immensity of the event, the door closed and he was alone again. He screamed, pounded the door, and demanded to see an attorney, but no answer came from behind the door. Finally, he collapsed on the stone floor and sobbed helplessly.

It was still dark when three men came into the cell. They took off his clothes and bound his hands. Naked he walked in front of them through the corridors of the former Institute of Physical Chemistry, which had served as a prison for the last years.

The cold outside made him shiver, but the men paid no attention and forced him to walk bare-foot to city square where he saw a scaffold erected in the middle surrounded by a crowd. Hanebb had not seen city square since his escape, and could hardly recognize the smoke filled place illuminated by hundreds of torches. In the past years the facades of the surrounding houses had been stripped to the bare stone, and now stared with black windows into the smoke clouds. It was as if the place had been transported several hundred years back in time. Drums beat monotonous rhythms accompanied by high-pitched flutes with discordant, twelve-tone melodies while Hanebb and his guards walked into the crowd that parted reluctantly as they approached. The people stared with hatred at Hanebb and continued to chant their monotonous sacred chorals. Hanebb recognized some of the melodies, because they were ancient pentatonic songs of the Karatas. However, the crowd did not sing them in recognition of Hanebb's ancestry, but because the Navals had banned any music unless is was based on chromatic or pentatonic scales.

Hanebb climbed up to the scaffold and a hooded guard led him over to a wooden cross in the shape of the T-pentomino which was slightly taller than he. Two men tied his spread arms to the crossbar while a third bound his legs to the stem.

At this, the crowd opened a passage between the scaffold and the temple across the square. The doors of the temple swung open to release a group of drum and flute players walking in front of two robed figures. They wore black and white robes symbolizing the 'thing' and the 'anti-thing'. They walked a few feet apart, as the space between them was to indicate the 'void'. Behind them followed five dancing virgins in yellow and blue robes carrying torches in their hands. They wore crowns with the symbols of the five elements. The changing constellations of the five dancers presented the eternal interplay of the five elements as they created the twelve shapes. In stark contrast to the swiftly moving dancers, a solemn group of eleven hooded figures followed, each carrying one of the sacred pentomino shapes. The T-shaped pentomino was missing. Upon arrival at the scaffold the members of the procession climbed up and the grouped themselves to the left and right of Hanebb's cross.

Finally, Cassanka emerged from the doors of the temple. He held the T-shaped pentomino high up as he walked with measured steps alone through the passage towards the scaffold. When he arrived, a hooded woman stepped forward and knelt down to receive the T-symbol. With his hands buried in his sleeves, Cassanka climbed onto the platform.

Hanebb's heart pounded wildly. He hardly felt the pain of the ropes which tied his arms to the cross. Could this really be true? Was this mad priest, who pathetically mumbled superstitious nonsense allowed to murder him publicly, him, Hanebb, one of the frontier scientists of molecular genetics? Was this the same world, in which airplanes flew between cities? He tried to tear the ropes, but in vain. He tried to awake from his nightmare, but there was no sleep other than death. Panic held him in its grip.

Suddenly, he was quiet. Cassanka stood in front of him with a five-jagged dagger in his hands. He raised it high above his head, and turning in a circle he showed it to the crowd which had fallen silent as well.

"In the name of the Holy Twelve, I hereby redeem thee.".

Cassanka spoke loud as he sank the dagger into Hanebb's heart.

Dawn of a new era

It was twenty years later. Compared to the turbulent beginning of the century, surprisingly little had changed. The sects had taken over the countries, but it made little difference for science. After Hanebb's crime, it was rapidly dying, anyway. People under the permanent influence of endogenous drugs cared little for the pleasures of rigorous thought. Science simply faded away. Only medicine continued to exist. How bizarre, thought Lao, like the emperor many thousand years ago, Hanebb, another Karata, had interrupted any further development of science.

The people had learned to live with the 'drug-bug', as they called the virus. After an initial epidemic incidence of fatal tumors, a population emerged that did not develop any more tumors. Apparently, their brain had amplified some other genes that were related to the stimulant called adrenalin. These compounds were released into the blood stream during every attack of the α-endorphin and countered its sedating effect with a stimulating anti-effect. Unfortunately, the adrenalin concentration in the blood increased as late as thirty minutes after a α-endorphin attack. As a result, people went through terrifying phases of alternating depression and euphoria. Yet, they had learned to accept it. People always learned to accept.

There was a most peculiar new development. Over the past five years there had been various reports of isolated cases of children, who developed a new kind of large growth of brain-tissue near their forehead. Yet, they did not die as infants. In fact, their frontal tissue growth had yet to be examined by an autopsy, because all of them were still alive.

These children were obviously abnormal, yet not ill or incapacitated. Their blood levels of α-endorphin and adrenalin were permanently high. They resembled each other strikingly, not only because of their enlarged foreheads. Judging by their faces, they could all have been siblings. Their speech was highly developed, although they seemed unwilling to speak. Their learning abilities were a matter of controversy. While some observers maintained that they had the highest level of intelligence ever encountered in people, others declared them as retarded. Lao found it strange that there could ever be a disagreement on such matters, but he could not judge for himself, since he had never met one of them. The only explanation for the different assessment that he could find was the shyness of these children to speak.

People called them 'Karma-children'. Nobody knew the origin of the name, but somehow it expressed the magic that seemed to surround them.

Lao's hair had turned white. The turn of the millennium was upon the world, and he wondered with a somewhat detached curiosity, what the next millennium without science would bring. Fatigued by the marvels and horrors of the present millennium he looked at the world as a survivor of a catastrophe: distant, fearless, knowing. He continued his studies of the brain, although he knew that nobody would ever read or hear about them. There was no more science, no more publication, no interchange of data and ideas. His knowledge would be buried with him.

At least it was no longer dangerous for him to pursue his scientific interests. He was a senior pathologist at the Ro'alam hospital, which entailed the permission to carry out autopsies. Besides, the sects no longer persecuted science, since nothing was left to persecute.

On the first weekend after the Palanar holidays, Lao was unexpectedly called to perform an autopsy. Hospital officials were interested in the case, and he hurried over to the morgue. There lay the body of a five year old Karma-child, the victim of a traffic accident.

Lao began the necessary preparations to preserve the brain of the child for future examination. Then he began to open the skull along the temples and presently lifted the cranium.

For a long time he stared in disbelief. There were legends of ancient kings who were chosen by the Gods to see the future of their people shortly before their death. The old Lao was chosen to see eons into the future of mankind.

The mass of tissue that divided the two hemispheres underneath the hump was not a tumor. It was a delicately structured organ with countless geometric ridges that formed a honeycomb pattern over its surface. It protruded from the position of the ancient first brain and stretched toward the dorsal side following the cleft between the hemispheres where it made numerous connections with the lower strata of the second brain. Near the front it thickened and rose above an intricate braid of nerves, a plexus of immense complexity, that covered the surface of what had formerly been the final third brain.

Millions of years after the third brain had driven its children to rise to awareness, to retool the planet with machines, to turn abstract thought into science, and to unleash weapons of unprecedented destructive power that brought mankind nearly to its end, the dawn of a new era rose before Lao.

Unable to fathom the power of its successor, his primitive triplet brain tried to cope with the magnificence and the deadly threat of the fourth brain before him.

Yet, all he could feel was awe and fatigue and an overpowering love for his fellow children of the third brain. Soon they would succumb to the new species, would perish and be no more than a fossil entry on one of the rocky pages of Gabo's crust. It was over. All the splendor and courage, all the fear and sacrifice had been but a stepping stone for evolution.