OBSERVING LANDSCAPES

Riparian Construction in the 21st Century
Another Moment in the History of Discovery

Green trees cover the banks as if struggling to conceal the surface of the river. This lush setting offers glimpses of a (broken) system. Can we, like Copernicus or Mendel, see what others have not seen when looking at the same landscape?

Dr. Yukihiro Shimatani
River Ecology Team Leader and senior researcher, Water Environment Research Group, Public Works Research Institute (an independent administrative institution). Shimatani, a native of Yamaguchi Prefecture, was born in 1955. He has a doctorate in engineering and received a masters degree in engineering research from the Graduate School of Engineering, Kyushu University, and has been involved both professionally and as a private citizen in river improvement plans designed to make possible a richer riparian environment throughout Japan.

Aqua Restoration Research Center
A place to experience a change of direction

A canal is dug from the Shinsakai River, a branch of the Kiso River, and then connects back to the Shinsakai. Created by human hands, this bypass canal is an artificial river so new it has gathered no moss. How many living things will migrate here? Will fish be among them? We could assemble illustrious civil engineers from all over Japan to ask them those questions, and what would they say? “We don’t really know....”

That at least was the situation when the Ministry of Construction formed a committee to study the question in November, 1998, the same month that saw the opening of the Aqua Restoration Research Center in Hashima County in Gifu Prefecture.

“Our work began with that basic question,” said Dr. Yukihiro Shimatani, who has been centrally involved in the center’s activities from the planning stages. “All over Japan, work was beginning on restoring rivers to their pristine natural state, so the questions were natural. People were saying, ‘Even if you tear out the concrete, living things won't come back soon’ or ‘Even if the river snakes around like it used to, is that enough to increase the fish population?’ It seemed commonsensical that living things would prefer winding rivers, but since tax money would be used, we had to be able to predict specific effects. That is why the center was created, to conduct the necessary experiments.”

Located along the Kiso River, the center occupies a 13-hectare site that includes 800 meters of experimental rivers and experimental ponds. There are three experimental rivers, River A, which has a nearly straight channel between concrete banks, and B and C which snake along through shallows and deep pools.

Since World War II, most riparian projects in Japan have been aimed at flood control. Rivers were confined to straight courses within concrete banks to ensure that their waters were discharged directly into the sea. Experimental River A models this classic pattern.

But returning, then, to the original question, what does the center’s research have to say? From the very day that water was allowed to flow through them, fish returned to all three experimental rivers and began to lay their eggs. That answered the first question. Next, it was time to compare the three rivers.

In the spring of 1999, the researchers used electric current to stun the fish in the three experimental rivers, to count their fish population. Winding rivers B and C yielded more fish of more species: 627 fish of seven different species in B and 987 fish of 10 different species in C. Straight River A yielded only 130 fish of only four species. Here was experimental proof that winding rivers, with their variations in speed of flow and water depth, supported a richer and more diverse ecosystem.

“Anyone who visits the center can share this experience. That is very important. It helps, for example, civil engineers to understand the significance of keeping rivers as close to their natural state as possible. Their long-engrained work habits are hard to break. It is very difficult to turn their heads around. But when they witness the rich ecosystem more natural rivers support at the center, they become more understanding. Also, at the center, practical engineers and ecologists can work together on joint research projects designed to restore the environment to its natural state. This idea itself was totally missing during the twentieth century. It is truly a great example of flexibility in pursuing scientific inquiry.”

The front line of river improvement
Cutting down trees for the sake of the environment

At this point, we expected to continue with a more detailed look at the center’s facilities. Then, however, Dr. Shimatani shifted the conversation away from the simplistic idea that the more living things there are, the better the environment. “That is actually a difficult question,” he said. “Generally speaking it’s true, but strictly speaking it’s not. Japan has many different kinds of environments where many different living things find niches. In some cases, however, dry riverbeds, for example, we find an unhealthy situation in which there are living things that don't belong where we find them. Riverbeds should look like riverbeds.”

But what could be unnatural about a dry riverbed? “It’s not right to have trees growing in riverbeds,” says Dr. Shimatani, starting up his notebook PC and showing images of riverbanks.

“These are pictures of the Tama River. Tomorrow we have a research meeting at which we will discuss cutting down the trees on its banks to preserve the natural environment. It will be the first

■ Aqua Restoration Research Center

Located in Kawashima-cho on a 13-hectare site in the Kiso River flood plain, the Center has three experimental rivers and six experimental ponds as well as research laboratories. With a total length of 800 meters, its artificial experimental rivers are the longest in the world.

■ Results of Flooding Experiments

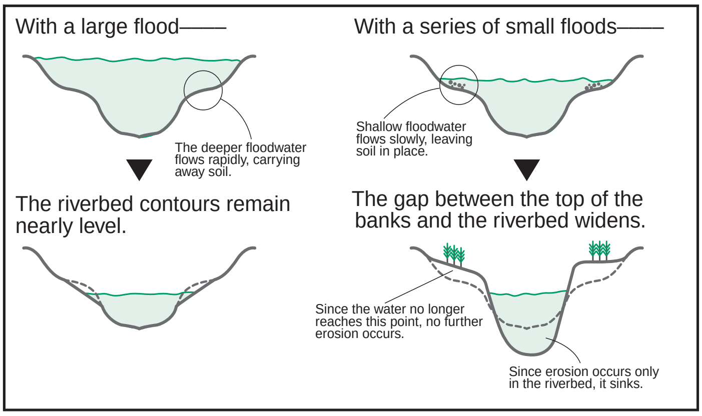
Experimental river following flood C

Experimental river with no flood B

Of the two winding experimental rivers, the one which was flooded revealed sprouts and seeds carried by the flood, removal of excess earth, and preservation of the riverside ecology.

■ Scale of Flood and Changes in River

Relatively large floods prevent widening the height difference between the top of the riverbanks and riverbeds, but a series of small floods accelerates the growth of that gap.



time in Japan that trees have been cut down in an effort to restore a dry riverbed."

Comparing these images to photographs of the Tama River taken in 1947, it is obvious that the riverbed has shrunk. If it continues to contract, restoring it to its natural state will be out of the question. "In the past the riverbed and the surrounding land were on nearly the same level. Now the river has eaten deeper into the land; there is a substantial gap between the riverbed and the land beside it. If this process continues, the banks will resemble a hillside environment. Trees will cover the banks, and the dry riverbed will disappear. There is a real danger that organisms native to the riverbed environment, like certain chrysanthemums and grasshoppers, for example, will become extinct."

Why has the river cut deeper into the land? If this is a natural process, what can humans do but watch it happen?

"In the past, the river was subject to periodic floods that restored the dry riverbed by destroying the vegetation that tends to grow over it. But human interference has unbalanced this dynamic process. With dams on the river, for example, the water flow is nearly constant year round. That has important benefits, but the other side of the coin is an extremely monotonous environment." Like a digital signal, the river has its highs and lows; with a dam blocking them, it ends up building banks, in a roundabout way. "There is a close relationship between the frequency of immersion in water and the types of vegetation that grow by the river. Grass grows right at the river's edge. A little further away you find willows. Willows are weak competitors compared to other trees. If we plant them in hilly terrain, they soon die off. They are, however, highly resistant to damage from flooding and can survive closer to the river. All organisms have their own survival strategies. When the environment changes, the living things that inhabit it also change."

In the images displayed on the notebook PC, we see the spreading branches of the false acacia, a variety of trees adapted to a drier environment.

Landscape as a system

Nature doesn't return naturally

Two of the Aqua Restoration Research Center's experimental rivers are winding rivers. Winding River C is designed to allow a sudden inrush of water to simulate flooding. The results of experiments using this river can be summed up in the proposition that flooding on different scales produces radically different results. As shown in the figure, repeated small floods deepen the riverbed and increase the gap between the riverbed and the land.

"It is a little-known fact that this phenomenon is occurring worldwide. It is thought that, since World War II, riverbeds have sunk three meters in Japan."

Floods can have a healing effect by restoring a lost ecology. That is why plans to temporarily open dams to create artificial floods are now being considered. Using the wrong protocol could, however, make a pathological ecosystem worse. Trying to determine how much water should be released to create an artificial flood is one of Dr. Shimatani's most vital tasks.

When talking about involvement with river ecology in an effort to restore the original landscape, we must take care to define our terms. If all we are talking about is the visible landscape, replacing concrete embankments with trees and rocks, that isn't enough to restore a river to its natural state.

"In nature, things naturally fit together. In the case of flood plains, the landscape we see is a system composed of floods and the sediments carried down from upriver. To restore that landscape we have to restore the system. Superficial changes won't produce lasting change. For the sake of convenience, however,

■ Changes in the Tama River's Dry Riverbed

1947

1989

As forestation advances, the dry riverbed shrinks. Chrysanthemums, mugworts and grasshoppers that live in the dry riverbed environment face extinction.

The false acacia, a tree adapted to a mountainous environment.

■ On the Front Lines of River Improvement

The relation of flood control to the natural environment varies from river to river. Sometimes both can be improved simultaneously. Sometimes improvements are limited to the natural environment. There are also times when flood control unavoidably imposes a burden on the environment. Here the discussion is, "If we improve flood control any further, the damage to the environment will be much greater." In these types of situations, Dr. Shimatani is often called in. He travels throughout Japan. (The day before our interview he was in Hokkaido for a research meeting concerning the Shibetsu River.)

"A citizens group in Asaka City in Saitama Prefecture asked me to consult on improvement plans for the Kurome River. First I took a digital camera and photographed the environment at 100-meter intervals. As we looked at the images with the group, I listened to their specific requests, e.g., 'Couldn't we save that cherry tree?' Then someone would comment, 'In that case the water margin would be here, so let's make this change,' and on we worked, gradually refining the plan. The whole project is only two kilometers long, but we met to discuss it twelve times. The digital camera was very useful in helping us reach an agreement. The images could be projected on a whiteboard, so we could write comments on top of them. If there were only some way to reproduce the comments together, it would be even easier." (Dr. Yukihiro Shimatani)

we may have to change some parts of the system. Balancing these competing demands is very difficult."

Nature will no longer restore itself if left to its own devices. That is why we must work to understand the system behind the landscape, and the Aqua Restoration Research Center is the backbone of this effort.

As we were leaving, we asked Dr. Shimatani, pointing to the Sumida River, which flows near the Tokyo venue for our interview, "What about that river?" Our interview took place near the river. "If you are trying to rehabilitate the Sumida," he said, "rape blossoms and lotus flowers are more important than, for example, building a hiking course. The goal is the image in the song The Banks of the Sumida, 'The Sumida on a beautiful, mild, clear spring day. . . .'" "Is that still possible? Starting now?"

"Well," says Dr. Shimatani, stopping for a moment, "what I know for certain is that if we think we cannot do it, it will be impossible, absolutely. We must be committed to taking action. If we are, then everyone else will say, 'Yes, it's possible'."

Dissecting tales of genius
A long process of discovery

The apple falls from the tree, a flash of inspiration occurs, the theory of gravitation is discovered. No tale of discovery is more popular. We know, however, that in 1666, the year in which that falling apple caught Newton's eye, gravity wasn't a new idea. Newton's achievement was to use it to explain planetary motion. In fact, some say the story of the apple may be nothing more than an "alibi" conceived by Newton to secure his place in the history of ideas.

While tales of sudden, accidental discoveries are widespread and familiar, it can be very interesting to offer other explanations for them. Serendipitous Science, a book on the relation between serendipity and creativity, is full of such alternative explanations. We met with the author, Dr. Hiroyuki Iyama, to discuss how different observers discover different things in the landscapes around them.

We met with Dr. Iyama at the Faculty of Humanities at Niigata University. He put two pages of copies on his desk and said, "I was just teaching this topic. It has to be discussed on two levels."

1. Discovery isn't a one-day affair but a history of sorting and sifting

As shown in the left diagram on the next page, six major models of the cosmos had appeared by the seventeenth century. "While in the end only the Copernican model (lower right: VI) would survive, it took more than a hundred years to achieve that result. We tend to think of innovation as something that happens instantaneously. If we look behind the tales that describe discoveries, however, we always find a long path of exploration and testing. In other words, there is always a history of sorting and sifting that led to rejection of other ideas.

Consider, for example, the Ptolemaic model of the universe (upper left: I), which was held to be true for more than a thousand years. Its principles are truly elegant. This model's most elegant feature is its use of perfect circles. But in this respect the Copernican model is misshapen. When it was announced, it would not have been seen as a radically new idea."

The other illustration on the next page is taken from a book published in 1651, one hundred eight years after Copernicus announced his model in 1543. "In it we see the Ptolemaic model lying on the floor. It is no longer a serious competitor for the Copernican model. The Copernican model is being weighed against Tycho's model. Since, however, the truer model is supposed to have the weight of the evidence on its side, we can see that an eclectic model still has more support than the Copernican model. It wasn't until the Copernican model received the support of Galileo

Dr. Hiroyuki Iyama
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In the figures on the left, I. is the Ptolemaic system, in which the earth is the center of the universe; VI. is the Copernican model, with the earth revolving around the sun. V. is a revision of Tycho's model, shown as IV, in which the sun revolves around the earth but Mercury, Venus, and Mars revolve around the sun. The figure on the right is the illustration of a book published in 1651; it seems to give more weight to the modified Tychonic system than to the Copernican model.

that it was fully accepted."

We may believe that truth strikes like lighting and is instantly accepted by society: Dr. Iyama's examples have destroyed the second of these premises.

Reconstructing tales of genius
Creativity surrounded by rubble

2. Thought Separated from Its Springboard—Changing the Code

"Next, we have to at least ask ourselves what kind of thing is inspiration. The Copernican model with the sun at the center seemed irrational at the time it was proposed, because, from a Christian point of view, the sun was the god of heathen religions. To place the sun in the center of the cosmos seemed diabolical. Copernicus didn't accept that assumption. He was the sort of thinker whose thought could separate itself from its springboard. Only, however, when society was ready to change its assumptions were his ideas recognized as a breakthrough.

"First at the individual level, Copernicus himself had to change his society's assumptions, i.e., transform its code for himself. Then the change had to be propagated throughout society. It is only when both of these processes have been completed that we can talk about a discovery."

Changing the code at the individual level means going out on a limb, from the perspective of the rest of society. "That was true even of semiconductors. The tunneling effect was unimaginable to ordinary thinking. The usual assumption was that processes are linear and couldn't suddenly jump to a different plane."

But what is important to realize is that even in changing the code at the individual level, more is involved that individual genius. "In every era, many people are out of tune with the times. But most are simply mistaken. Creativity is a tree that grows from the rubble of mistakes. The history of science is the history of reconstructing processes, tearing away the branches."

Only what history has demonstrated to be of value can be the subject of tales of discovery. But value judgments swing back and forth. The Copernican model was once rejected as erroneous. In the moment of inspiration, at the starting line, all ideas are equal. But to seek the truth only in strokes of genius is to distort the earlier stages in a discovery's story.

Did even Copernicus himself perceive the "truth" directly? "In the introduction to his work, Copernicus writes something interesting. Ordinarily those who wish to do something new stress the claim that they have no predecessors. Copernicus, however, strives with all his might to tell us about his predecessors. He tells us about Aristarchos from the island of Samos who had the same idea. He also mentions Herakleitos to demonstrate that his idea is not that remarkable. That is why, he says, we ought to read his work. Originality in the sense that Copernicus use it means work solidly based on origins. What Copernicus was trying to do was to rediscover the truth in ancient ideas."

To those making new discoveries, the process of self-clarification is more important that the sudden moment of insight. Mendel is a case in point.

"What motivated Mendel was the desire to explicate, systematically, like an alphabet, the mysterious genetic code at work in our bodies. He assumed a priori that a three-to-one ratio of dominant to recessive traits would appear in the peas he studied. It is only in this light that we can understand his experiments."

Herakleitos (Ancient Greek) — c. 540 BC
He discarded his status as a member of a famous family to pursue a solitary life devoted to philosophy. He saw the natural world as constantly changing (Everything flows) but saw the change as regulated by a fixed principle (logos).

Aristarchos (Ancient Greek) — 310-230 BC
Born on the island of Samos in the Aegean Sea. He measured the distance between the earth and the sun and the moon. While his calculations were flawed, he is credited for proposing a cosmology in which the earth moved.

Ptolemaios Klaudios (Egyptian) — second century
An astronomer and geographer who lived and worked in Alexandria. In his *Almagest*, he systematized ancient astronomy, argued that heavenly bodies moved, and supported Christianity.

Nicolaus Copernicus (Polish) — 1473-1543
While studying in Italy, he discovered the work of Aristarchos and wrote *On the revolutions of the heavenly spheres (De revolutionibus orbium coelestium)*, arguing that the earth travels around the sun. He received his first printed copy of the book on his deathbed.

Brahe Tycho (Danish) — 1546-1601
He overturned the conventional wisdom of his time that the heavens are unchanging by his observations of a new star appearing in the constellation Cassiopeia. He collected massive amounts of astronomical data, and his work was carried on by his assistant Kepler.

Galileo Galilei (Italian) — 1564-1642
The father of modern science. He is said to have been the first human being to use a telescope to explore the heavens. He was prosecuted by the Church for supporting the Copernican theory that the earth revolves around the sun. In 1983, the Pope revoked the Church's judgment on his work.

Isaac Newton (English) — 1642-1727
Born in the year that Galileo died, he proved the physical laws behind Kepler's observations of planetary motion. He quarreled with Leibniz and Cook over who was the first to make scientific discoveries.

And he was right. The traits he studied appeared in constant proportions: three-fourths of the peas showed the dominant trait and one-fourth showed the recessive.

Deviation, motivation, obsession: in the case of those who make major breakthroughs what is remarkable is less the fact that they made serendipitous discoveries than that their turning out to be right was itself serendipitous.

“More than going on about serendipity, we should recognize that they observed carefully and drew meaning from what they observed—that’s the process that has uniqueness, that we ought to emphasize. It’s something like pattern recognition; they saw what everyone saw but saw it from a different perspective or in terms of a different gestalt.”

Impressionist painters didn’t make a point of calling themselves impressionists. It was just that they saw landscapes in that particular way. It was outsiders who labeled them “impressionists” after the fact.

The same can be said of discoverers. It is because discoverers see things in a different way that they come to be called discoverers.

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“It's strange,” says Dr. Iyama. “Discoveries and the unexpected have certain similarities. We call something unexpected when we attach that significance to it. Mahjong is a good example. Someone who doesn’t understand the tiles may hold a winning hand but play it randomly. It is only given the rules as our premise, that the order of their moves feels so unexpected. Even though, to be accurate, it would be the same if they held a lousy hand.”

Copernicus says, “Look, what an extraordinary hand I have.”

Everyman replies, “What are you saying, it's a lousy hand.”

Copernicus says, “What are you saying. Look, it's so beautiful.”

Everyman replies, “That is why I said it’s worthless.”

Galileo chimes in, “Well, this is truly a hand that we have never seen before. Let’s change the rules and make it a winner.”

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What concerns Dr. Iyama is the way in which people these days worry so much about probability. But what does modern society really mean by probability, a 20 percent chance of rain, or an 85 percent chance of success for an operation? Probability implies something different from the unexpected. So achieving probability means that everyone has to see the same meaning whatever the situation.

The probability of waking up at 7:00 a.m., the probability of burning a fried egg for breakfast—it is by living amidst countless probabilities that people feel that they lead meaningful lives. If, however, we see this as an unexpected tragedy, we need to look for ways to rise above it.

We asked Dr. Iyama why he switched from the Chemistry Department in the School of Science to the history of scientific thought.

“There were many different reasons, but one was a girlfriend whose father was a chemist. She hated the acetone smell from his experiments.”

We could only smile.

“But that's a partially reconstructed tale. According to a friend, when Inoue and Iyama were paired at the same lab bench, the experiments always went poorly. One time, we managed to produce cyanide gas by accident—what a fuss that caused! What happened to Inoue? He passed the bar and became a judge.”