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The Picture Problem

Mammography, air power, and the limits of looking.

by Malcolm Gladwell

1.

At the beginning of the first Gulf War, the United States Air Force dispatched two squadrons of F-15E Strike Eagle fighter jets to find and destroy the Scud missiles that Iraq was firing at Israel. The rockets were being launched, mostly at night, from the backs of modified flatbed tractor-trailers, moving stealthily around a four-hundred-square-mile "Scud box" in the western desert. The plan was for the fighter jets to patrol the box from sunset to sunrise. When a Scud was launched, it would light up the night sky. An F-15E pilot would fly toward the launch point, follow the roads that crisscrossed the desert, and then locate the target using a state-of-the-art, \$4.6-million device called a LANTIM navigation and targeting pod, capable of taking a high-resolution infrared photograph of a four-and-a-half-mile swath below the plane. How hard

could it be to pick up a hulking tractor-trailer in the middle of an empty desert?

Almost immediately, reports of Scud kills began to come back from the field. The Desert Storm commanders were elated. "I remember going out to Nellis Air Force Base after the war," Barry Watts, a former Air Force colonel, says. "They did a big static display, and they had all the Air Force jets that flew in Desert Storm, and they had little placards in front of them, with a box score, explaining what this plane did and that plane did in the war. And, when you added up how many Scud launchers they claimed each got, the total was about a hundred." Air Force officials were not guessing at the number of Scud launchers hit; as far as they were concerned, they knew. They had a four-million-dollar camera, which took a nearly perfect picture, and there are few cultural reflexes more deeply ingrained than the idea that a picture has the weight of

truth. "That photography not only does not, but cannot lie, is a matter of belief, an article of faith," Charles Rosen and Henri Zerner have written. "We tend to trust the camera more than our own eyes." Thus was victory declared in the Scud hunt--until hostilities ended and the Air Force appointed a team to determine the effectiveness of the air campaigns in Desert Storm. The actual number of definite Scud kills, the team said, was zero.

The problem was that the pilots were operating at night, when depth perception is impaired. LANTIM could see in the dark, but the camera worked only when it was pointed in the right place, and the right place wasn't obvious. Meanwhile, the pilot had only about five minutes to find his quarry, because after launch the Iraqis would immediately hide in one of the many culverts

underneath the highway between Baghdad and Jordan, and the screen the pilot was using to scan all that desert measured just six inches by six inches. "It was like driving down an interstate looking through a soda straw," Major General Mike DeCuir, who flew numerous Scud-hunt missions throughout the war, recalled. Nor was it clear what a Scud launcher looked like on that screen. "We had an intelligence photo of one on the ground. But you had to imagine what it would look like on a black-and-white screen from twenty thousand feet up and five or more miles away," DeCuir went on. "With the resolution we had at the time, you could tell something was a big truck and that it had wheels, but at that altitude it was hard to tell much more than that." The postwar analysis indicated that a number of the targets the pilots had hit were actually decoys, constructed by the Iraqis from old trucks and spare missile parts. Others were tanker trucks transporting oil on the highway to Jordan. A tanker truck, after all, is a tractor-trailer hauling a long, shiny cylindrical object, and, from twenty thousand feet up at four hundred miles an hour on a six-by-six-inch screen, a long, shiny cylindrical object can look a lot like a

missile. "It's a problem we've always had," Watts, who served on the team that did the Gulf War analysis, said. "It's night out. You think you've got something on the sensor. You roll out your weapons. Bombs go off. It's really hard to tell what you did."

You can build a high-tech camera, capable of taking pictures in the middle of the night, in other words, but the system works only if the camera is pointed in the right place, and even then the pictures are not self-explanatory. They need to be interpreted, and the human task of interpretation is often a bigger obstacle than the technical task of picture-taking. This was the lesson of the Scud hunt: pictures promise to clarify but often confuse. The Zapruder film intensified rather than dispelled the controversy surrounding John F. Kennedy's assassination. The videotape of the beating of Rodney King led to widespread uproar about police brutality; it also served as the basis for a jury's decision to acquit the officers charged with the assault. Perhaps nowhere have these issues been so apparent, however, as in the arena of mammography. Radiologists developed state-of-the-art X-ray cameras and used them to scan women's breasts for tumors, reasoning that, if you

can take a nearly perfect picture, you can find and destroy tumors before they go on to do serious damage. Yet there remains a great deal of confusion about the benefits of mammography. Is it possible that we place too much faith in pictures?

2.

The head of breast imaging at Memorial Sloan-Kettering Cancer Center, in New York City, is a physician named David Dershaw, a youthful man in his fifties, who bears a striking resemblance to the actor Kevin Spacey. One morning not long ago, he sat down in his office at the back of the Sloan-Kettering Building and tried to explain how to read a mammogram.

Dershaw began by putting an X-ray on a light box behind his desk. "Cancer shows up as one of two patterns," he said. "You look for lumps and bumps, and you look for calcium. And, if you find it, you have to make a determination: is it acceptable, or is it a pattern that might be due to cancer?" He pointed at the X-ray. "This woman has cancer. She has these tiny little calcifications. Can you see them? Can you see how small they are?" He took out a magnifying glass and placed it over a series of white flecks; as a cancer grows, it produces calcium

deposits. "That's the stuff we are looking for," he said.

Then Dershaw added a series of slides to the light box and began to explain all the varieties that those white flecks came in. Some calcium deposits are oval and lucent. "They're called eggshell calcifications," Dershaw said. "And they're basically benign." Another kind of calcium runs like a railway track on either side of the breast's many blood vessels--that's benign, too. "Then there's calcium that's thick and heavy and looks like popcorn," Dershaw went on. "That's just dead tissue. That's benign. There's another calcification that's little sacs of calcium floating in liquid. It's called 'milk of calcium.' That's another kind of calcium that's always benign." He put a new set of slides against the light. "Then we have calcium that looks like this--irregular. All of these are of different density and different sizes and different configurations. Those are usually benign, but sometimes they are due to cancer. Remember you saw those railway tracks? This is calcium laid down inside a tube as well, but you can see that the outside of the tube is irregular. That's cancer." Dershaw's explanations were beginning to be confusing. "There are certain calcifications in benign tissues that are

always benign," he said. "There are certain kinds that are always associated with cancer. But those are the ends of the spectrum, and the vast amount of calcium is somewhere in the middle. And making that differentiation, between whether the calcium is acceptable or not, is not clear-cut."

The same is true of lumps. Some lumps are simply benign clumps of cells. You can tell they are benign because the walls of the mass look round and smooth; in a cancer, cells proliferate so wildly that the walls of the tumor tend to be ragged and to intrude into the surrounding tissue. But sometimes benign lumps resemble tumors, and sometimes tumors look a lot like benign lumps. And sometimes you have lots of masses that, taken individually, would be suspicious but are so pervasive that the reasonable conclusion is that this is just how the woman's breast looks. "If you have a CAT scan of the chest, the heart always looks like the heart, the aorta always looks like the aorta," Dershaw said. "So when there's a lump in the middle of that, it's clearly abnormal. Looking at a mammogram is conceptually different from looking at images elsewhere in the body. Everything else has anatomy--anatomy that essentially looks the same from one person to

the next. But we don't have that kind of standardized information on the breast. The most difficult decision I think anybody needs to make when we're confronted with a patient is: Is this person normal? And we have to decide that without a pattern that is reasonably stable from individual to individual, and sometimes even without a pattern that is the same from the left side to the right."

Dershaw was saying that mammography doesn't fit our normal expectations of pictures. In the days before the invention of photography, for instance, a horse in motion was represented in drawings and paintings according to the convention of *ventre à terre*, or "belly to the ground." Horses were drawn with their front legs extended beyond their heads, and their hind legs stretched straight back, because that was the way, in the blur of movement, a horse seemed to gallop. Then, in the eighteen-seventies, came Eadweard Muybridge, with his famous sequential photographs of a galloping horse, and that was the end of *ventre à terre*. Now we knew how a horse galloped. The photograph promised that we would now be able to capture reality itself.

The situation with mammography is different. The way in which we ordinarily speak about calcium and lumps is clear and unambiguous. But the picture demonstrates how blurry those seemingly distinct categories actually are. Joann Elmore, a physician and epidemiologist at the University of Washington Harborview Medical Center, once asked ten board-certified radiologists to look at a hundred and fifty mammograms--of which twenty-seven had come from women who developed breast cancer, and a hundred and twenty-three from women who were known to have been healthy. One radiologist caught eighty-five per cent of the cancers the first time around. Another caught only thirty-seven per cent. One looked at the same X-rays and saw suspicious masses in seventy-eight per cent of the cases. Another doctor saw "focal asymmetric density" in half of the cancer cases; yet another saw no "focal asymmetric density" at all. There was one particularly perplexing mammogram that three radiologists thought was normal, two thought was abnormal but probably benign, four couldn't make up their minds about, and one was convinced was cancer. (The patient was

fine.) Some of these differences are a matter of skill, and there is good evidence that with more rigorous training and experience radiologists can become better at reading breast X-rays. But so much of what can be seen on an X-ray falls into a gray area that interpreting a mammogram is also, in part, a matter of temperament. Some radiologists see something ambiguous and are comfortable calling it normal. Others see something ambiguous and get suspicious.

Does that mean radiologists ought to be as suspicious as possible? You might think so, but caution simply creates another kind of problem. The radiologist in the Elmore study who caught the most cancers also recommended immediate workups--a biopsy, an ultrasound, or additional X-rays--on sixty-four per cent of the women who didn't have cancer. In the real world, a radiologist who needlessly subjected such an extraordinary percentage of healthy patients to the time, expense, anxiety, and discomfort of biopsies and further testing would find himself seriously out of step with his profession. Mammography is not a form of medical treatment, where doctors are justified in going to heroic lengths on behalf of their patients. Mammography is a form of medical screening:

it is supposed to exclude the healthy, so that more time and attention can be given to the sick. If screening doesn't screen, it ceases to be useful.

Gilbert Welch, a medical-outcomes expert at Dartmouth, has pointed out that, given current breast-cancer mortality rates, nine out of every thousand sixty-year-old women will die of breast cancer in the next ten years. If every one of those women had a mammogram every year, that number would fall to six. The radiologist seeing those thousand women, in other words, would read ten thousand X-rays over a decade in order to save three lives--and that's using the most generous possible estimate of mammography's effectiveness. The reason a radiologist is required to assume that the overwhelming number of ambiguous things are normal, in other words, is that the overwhelming number of ambiguous things really are normal. Radiologists are, in this sense, a lot like baggage screeners at airports. The chances are that the dark mass in the middle of the suitcase isn't a bomb, because you've seen a thousand dark masses like it in suitcases before, and none of those were bombs--and if you flagged every suitcase

with something ambiguous in it no one would ever make his flight. But that doesn't mean, of course, that it isn't a bomb. All you have to go on is what it looks like on the X-ray screen--and the screen seldom gives you quite enough information.

3.

Dershaw picked up a new X-ray and put it on the light box. It belonged to a forty-eight-year-old woman. Mammograms indicate density in the breast: the denser the tissue is, the more the X rays are absorbed, creating the variations in black and white that make up the picture. Fat hardly absorbs the beam at all, so it shows up as black. Breast tissue, particularly the thick breast tissue of younger women, shows up on an X-ray as shades of light gray or white. This woman's breasts consisted of fat at the back of the breast and more dense, glandular tissue toward the front, so the X-ray was entirely black, with what looked like a large white, dense cloud behind the nipple. Clearly visible, in the black, fatty portion of the left breast, was a white spot. "Now, that looks like a cancer, that little smudgy, irregular, infiltrative thing," Dershaw said. "It's about five millimetres across." He looked at the X-ray for a

moment. This was mammography at its best: a clear picture of a problem that needed to be fixed. Then he took a pen and pointed to the thick cloud just to the right of the tumor. The cloud and the tumor were exactly the same color. "That cancer only shows up because it's in the fatty part of the breast," he said. "If you take that cancer and put it in the dense part of the breast, you'd never see it, because the whiteness of the mass is the same as the whiteness of normal tissue. If the tumor was over there, it could be four times as big and we still wouldn't see it."

What's more, mammography is especially likely to miss the tumors that do the most harm. A team led by the research pathologist Peggy Porter analyzed four hundred and twenty-nine breast cancers that had been diagnosed over five years at the Group Health Cooperative of Puget Sound. Of those, two hundred and seventy-nine were picked up by mammography, and the bulk of them were detected very early, at what is called Stage One. (Cancer is classified into four stages, according to how far the tumor has spread from its original position.) Most of the tumors were small, less than two centimetres. Pathologists grade a tumor's aggression according to such measures as the "mitotic count"--the rate at which the

cells are dividing--and the screen-detected tumors were graded "low" in almost seventy per cent of the cases. These were the kinds of cancers that could probably be treated successfully. "Most tumors develop very, very slowly, and those tend to lay down calcium deposits--and what mammograms are doing is picking up those calcifications," Leslie Laufman, a hematologist-oncologist in Ohio, who served on a recent National Institutes of Health breast-cancer advisory panel, said. "Almost by definition, mammograms are picking up slow-growing tumors."

A hundred and fifty cancers in Porter's study, however, were missed by mammography. Some of these were tumors the mammogram couldn't see--that were, for instance, hiding in the dense part of the breast. The majority, though, simply didn't exist at the time of the mammogram. These cancers were found in women who had had regular mammograms, and who were legitimately told that they showed no sign of cancer on their last visit. In the interval between X-rays, however, either they or their doctor had manually discovered a lump in their breast, and these "interval" cancers were twice as likely

to be in Stage Three and three times as likely to have high mitotic counts; twenty-eight per cent had spread to the lymph nodes, as opposed to eighteen per cent of the screen-detected cancers. These tumors were so aggressive that they had gone from undetectable to detectable in the interval between two mammograms.

The problem of interval tumors explains why the overwhelming majority of breast-cancer experts insist that women in the critical fifty-to-sixty-nine age group get regular mammograms. In Porter's study, the women were X-rayed at intervals as great as every three years, and that created a window large enough for interval cancers to emerge. Interval cancers also explain why many breast-cancer experts believe that mammograms must be supplemented by regular and thorough clinical breast exams. ("Thorough" is defined as palpation of the area from the collarbone to the bottom of the rib cage, one dime-size area at a time, at three levels of pressure--just below the skin, the mid-breast, and up against the chest wall--by a specially trained practitioner for a period not less than five minutes per breast.) In a major study of mammography's effectiveness--one of a pair

of Canadian trials conducted in the nineteen-eighties--women who were given regular, thorough breast exams but no mammograms were compared with those who had thorough breast exams and regular mammograms, and no difference was found in the death rates from breast cancer between the two groups. The Canadian studies are controversial, and some breast-cancer experts are convinced that they may have understated the benefits of mammography. But there is no denying the basic lessons of the Canadian trials: that a skilled pair of fingertips can find out an extraordinary amount about the health of a breast, and that we should not automatically value what we see in a picture over what we learn from our other senses.

"The finger has hundreds of sensors per square centimetre," says Mark Goldstein, a sensory psychophysicist who co-founded MammaCare, a company devoted to training nurses and physicians in the art of the clinical exam. "There is nothing in science or technology that has even come close to the sensitivity of the human finger with respect to the range of stimuli it can pick up. It's a brilliant instrument. But we simply don't trust our tactile sense as much as our visual sense."

4.

On the night of August 17, 1943, two hundred B-17 bombers from the United States Eighth Air Force set out from England for the German city of Schweinfurt. Two months later, two hundred and twenty-eight B-17s set out to strike Schweinfurt a second time. The raids were two of the heaviest nights of bombing in the war, and the Allied experience at Schweinfurt is an example of a more subtle--but in some cases more serious--problem with the picture paradigm.

The Schweinfurt raids grew out of the United States military's commitment to bombing accuracy. As Stephen Budiansky writes in his wonderful recent book "Air Power," the chief lesson of aerial bombardment in the First World War was that hitting a target from eight or ten thousand feet was a prohibitively difficult task. In the thick of battle, the bombardier had to adjust for the speed of the plane, the speed and direction of the prevailing winds, and the pitching and rolling of the plane, all while keeping the bombsight level with the ground. It was an impossible task, requiring complex trigonometric calculations. For a variety of reasons, including the technical challenges, the

British simply abandoned the quest for precision: in both the First World War and the Second, the British military pursued a strategy of "morale" or "area" bombing, in which bombs were simply dropped, indiscriminately, on urban areas, with the intention of killing, dispossessing, and dispiriting the German civilian population.

But the American military believed that the problem of bombing accuracy was solvable, and a big part of the solution was something called the Norden bombsight. This breakthrough was the work of a solitary, cantankerous genius named Carl Norden, who operated out of a factory in New York City. Norden built a fifty-pound mechanical computer called the Mark XV, which used gears and wheels and gyroscopes to calculate airspeed, altitude, and crosswinds in order to determine the correct bomb-release point. The Mark XV, Norden's business partner boasted, could put a bomb in a pickle barrel from twenty thousand feet. The United States spent \$1.5 billion developing it, which, as Budiansky points out, was more than half the amount that was spent building the atomic bomb. "At air bases, the Nordens were kept under lock and key in secure

vaults, escorted to their planes by armed guards, and shrouded in a canvas cover until after takeoff," Budiansky recounts. The American military, convinced that its bombers could now hit whatever they could see, developed a strategic approach to bombing, identifying and selectively destroying targets that were critical to the Nazi war effort. In early 1943, General Henry (Hap) Arnold--the head of the Army Air Forces--assembled a group of prominent civilians to analyze the German economy and recommend critical targets. The Advisory Committee on Bombardment, as it was called, determined that the United States should target Germany's ball-bearing factories, since ball bearings were critical to the manufacture of airplanes. And the center of the German ball-bearing industry was Schweinfurt. Allied losses from the two raids were staggering. Thirty-six B-17s were shot down in the August attack, sixty-two bombers were shot down in the October raid, and between the two operations a further hundred and thirty-eight planes were badly damaged. Yet, with the war in the balance, this was considered worth the price. When the damage reports came in, Arnold exulted, "Now we have got Schweinfurt!" He was wrong.

The problem was not, as in the case of the Scud hunt, that the target could not be found, or that what was thought to be the target was actually something else. The B-17s, aided by their Norden Mark XV's, hit the ball-bearing factories hard. The problem was that the picture Air Force officers had of their target didn't tell them what they really needed to know. The Germans, it emerged, had ample stockpiles of ball bearings. They also had no difficulty increasing their imports from Sweden and Switzerland, and, through a few simple design changes, they were able to greatly reduce their need for ball bearings in aircraft production. What's more, although the factory buildings were badly damaged by the bombing, the machinery inside wasn't. Ball-bearing equipment turned out to be surprisingly hardy. "As it was, not a tank, plane, or other piece of weaponry failed to be produced because of lack of ball bearings," Albert Speer, the Nazi production chief, wrote after the war. Seeing a problem and understanding it, then, are two different things.

In recent years, with the rise of highly accurate long-distance weaponry, the Schweinfurt problem has become even more acute. If

you can aim at and hit the kitchen at the back of a house, after all, you don't have to bomb the whole building. So your bomb can be two hundred pounds rather than a thousand. That means, in turn, that you can fit five times as many bombs on a single plane and hit five times as many targets in a single sortie, which sounds good--except that now you need to get intelligence on five times as many targets. And that intelligence has to be five times more specific, because if the target is in the bedroom and not the kitchen, you've missed him.

This is the issue that the United States command faced in the most recent Iraq war. Early in the campaign, the military mounted a series of air strikes against specific targets, where Saddam Hussein or other senior Baathist officials were thought to be hiding. There were fifty of these so-called "decapitation" attempts, each taking advantage of the fact that modern-day G.P.S.-guided bombs can be delivered from a fighter to within thirteen metres of their intended target. The strikes were dazzling in their precision. In one case, a restaurant was levelled. In another, a bomb burrowed down into a basement. But, in the end, every single strike failed. "The issue isn't accuracy," Watts, who has

written extensively on the limitations of high-tech weaponry, says. "The issue is the quality of targeting information. The amount of information we need has gone up an order of magnitude or two in the last decade."

5.

Mammography has a Schweinfurt problem as well. Nowhere is that more evident than in the case of the breast lesion known as ductal carcinoma in situ, or DCIS, which shows up as a cluster of calcifications inside the ducts that carry milk to the nipple. It's a tumor that hasn't spread beyond those ducts, and it is so tiny that without mammography few women with DCIS would ever know they had it. In the past couple of decades, as more and more people have received regular breast X-rays and the resolution of mammography has increased, diagnoses of DCIS have soared. About fifty thousand new cases are now found every year in the United States, and virtually every DCIS lesion detected by mammography is promptly removed. But what has the targeting and destruction of DCIS meant for the battle against breast cancer? You'd expect that if we've been catching fifty thousand early-stage cancers every year, we should be seeing a corresponding decrease in the number of late-stage invasive

cancers. It's not clear whether we have. During the past twenty years, the incidence of invasive breast cancer has continued to rise by the same small, steady increment every year.

In 1987, pathologists in Denmark performed a series of autopsies of women in their forties who had not been known to have breast cancer when they died of other causes. The pathologists looked at an average of two hundred and seventy-five samples of breast tissue in each case, and found some evidence of cancer--usually DCIS--in nearly forty per cent of the women. Since breast cancer accounts for less than four per cent of female deaths, clearly the overwhelming majority of these women, had they lived longer, would never have died of breast cancer. "To me, that indicates that these kinds of genetic changes happen really frequently, and that they can happen without having an impact on women's health," Karla Kerlikowske, a breast-cancer expert at the University of California at San Francisco, says. "The body has this whole mechanism to repair things, and maybe that's what happened with these tumors." Gilbert Welch, the medical-outcomes expert, thinks that we fail to understand the hit-or-miss

nature of cancerous growth, and assume it to be a process that, in the absence of intervention, will eventually kill us. "A pathologist from the International Agency for Research on Cancer once told me that the biggest mistake we ever made was attaching the word 'carcinoma' to DCIS," Welch says. "The minute carcinoma got linked to it, it all of a sudden drove doctors to recommend therapy, because what was implied was that this was a lesion that would inexorably progress to invasive cancer. But we know that that's not always the case."

In some percentage of cases, however, DCIS does progress to something more serious. Some studies suggest that this happens very infrequently. Others suggest that it happens frequently enough to be of major concern. There is no definitive answer, and it's all but impossible to tell, simply by looking at a mammogram, whether a given DCIS tumor is among those lesions which will grow out from the duct or part of the majority that will never amount to anything. That's why some doctors feel that we have no choice but to treat every DCIS as life-threatening, and in thirty per cent of cases that means a mastectomy, and in

another thirty-five per cent it means a lumpectomy and radiation. Would taking a better picture solve the problem? Not really, because the problem is that you don't know for sure what you're seeing, and as pictures have become better we have put ourselves in a position where we see more and more things that we don't know how to interpret. When it comes to DCIS, the mammogram delivers information without true understanding. "Almost half a million women have been diagnosed and treated for DCIS since the early nineteen-eighties--a diagnosis virtually unknown before then," Welch writes in his new book, "Should I Be Tested for Cancer?," a brilliant account of the statistical and medical uncertainties surrounding cancer screening. "This increase is the direct result of looking harder--in this case with 'better' mammography equipment. But I think you can see why it is a diagnosis that some women might reasonably prefer not to know about."

6.

The disturbing thing about DCIS, of course, is that our approach to this tumor seems like a textbook example of how the battle against cancer is supposed to work. Use a powerful camera. Take a detailed picture. Spot the tumor as early as possible.

Treat it immediately and aggressively. The campaign to promote regular mammograms has used this early-detection argument with great success, because it makes intuitive sense. The danger posed by a tumor is represented visually. Large is bad; small is better--less likely to have metastasized. But here, too, tumors defy our visual intuitions.

According to Donald Berry, who is the chairman of the Department of Biostatistics and Applied Mathematics at M. D. Anderson Cancer Center, in Houston, a woman's risk of death increases only by about ten per cent for every additional centimetre in tumor length. "Suppose there is a tumor size above which the tumor is lethal, and below which it's not," Berry says. "The problem is that the threshold varies. When we find a tumor, we don't know whether it has metastasized already. And we don't know whether it's tumor size that drives the metastatic process or whether all you need is a few million cells to start sloughing off to other parts of the body. We do observe that it's worse to have a bigger tumor. But not amazingly worse. The relationship is not as great as you'd think."

In a recent genetic analysis of breast-cancer tumors,

scientists selected women with breast cancer who had been followed for many years, and divided them into two groups--those whose cancer had gone into remission, and those whose cancer spread to the rest of their body. Then the scientists went back to the earliest moment that each cancer became apparent, and analyzed thousands of genes in order to determine whether it was possible to predict, at that moment, who was going to do well and who wasn't. Early detection presumes that it isn't possible to make that prediction: a tumor is removed before it becomes truly dangerous. But scientists discovered that even with tumors in the one-centimetre range--the range in which cancer is first picked up by a mammogram--the fate of the cancer seems already to have been set. "What we found is that there is biology that you can glean from the tumor, at the time you take it out, that is strongly predictive of whether or not it will go on to metastasize," Stephen Friend, a member of the gene-expression team at Merck, says. "We like to think of a small tumor as an innocent. The reality is that in that innocent lump are a lot of behaviors that spell a potential poor or good prognosis."

The good news here is that it might eventually be possible to screen breast cancers on a genetic level, using other kinds of tests--even blood tests--to look for the biological traces of those genes. This might also help with the chronic problem of overtreatment in breast cancer. If we can single out that small percentage of women whose tumors will metastasize, we can spare the rest the usual regimen of surgery, radiation, and chemotherapy. Gene-signature research is one of a number of reasons that many scientists are optimistic about the fight against breast cancer. But it is an advance that has nothing to do with taking more pictures, or taking better pictures. It has to do with going beyond the picture.

Under the circumstances, it is not hard to understand why mammography draws so much controversy. The picture promises certainty, and it cannot deliver on that promise. Even after forty years of research, there remains widespread disagreement over how much benefit women in the critical fifty-to-sixty-nine age bracket receive from breast X-rays, and further disagreement about whether there is enough evidence to justify regular mammography in women under fifty and over seventy. Is there any way to resolve the

disagreement? Donald Berry says that there probably isn't--that a clinical trial that could definitively answer the question of mammography's precise benefits would have to be so large (involving more than five hundred thousand women) and so expensive (costing billions of dollars) as to be impractical. The resulting confusion has turned radiologists who do mammograms into one of the chief targets of malpractice litigation. "The problem is that mammographers--radiology groups--do hundreds of thousands of these mammograms, giving women the illusion that these things work and they are good, and if a lump is found and in most cases if it is found early, they tell women they have the probability of a higher survival rate," says E. Clay Parker, a Florida plaintiff's attorney, who recently won a \$5.1 million judgment against an Orlando radiologist. "But then, when it comes to defending themselves, they tell you that the reality is that it doesn't make a difference when you find it. So you scratch your head and say, 'Well, why do you do mammography, then?'"

The answer is that mammograms do not have to be infallible to save lives. A modest estimate of

mammography's benefit is that it reduces the risk of dying from breast cancer by about ten per cent--which works out, for the average woman in her fifties, to be about three extra days of life, or, to put it another way, a health benefit on a par with wearing a helmet on a ten-hour bicycle trip. That is not a trivial benefit. Multiplied across the millions of adult women in the United States, it amounts to thousands of lives saved every year, and, in combination with a medical regimen that includes radiation, surgery, and new and promising drugs, it has helped brighten the prognosis for women with breast cancer. Mammography isn't as good as we'd like it to be. But we are still better off than we would be without it.

"There is increasingly an understanding among those of us who do this a lot that our efforts to sell mammography may have been over-vigorous," Dershaw said, "and that although we didn't intend to, the perception may have been that mammography accomplishes even more than it does." He was looking, as he spoke, at the mammogram of the woman whose tumor would have been invisible had it been a few centimetres to the right. Did looking at an X-ray like

that make him nervous? Dershaw shook his head. "You have to respect the limitations of the technology," he said. "My job with the mammogram isn't to find what I can't find with a mammogram. It's to find what I can find with a mammogram. If I'm not going to accept that, then I shouldn't be reading mammograms."

7.

In February of last year, just before the start of the Iraq war, Secretary of State Colin Powell went before the United Nations to declare that Iraq was in defiance of international law. He presented transcripts of telephone conversations between senior Iraqi military officials, purportedly discussing attempts to conceal weapons of mass destruction. He told of eyewitness accounts of mobile biological-weapons facilities. And, most persuasively, he presented a series of images--carefully annotated, high-resolution satellite photographs of what he said was the Taji Iraqi chemical-munitions facility.

"Let me say a word about satellite images before I show a couple," Powell began. "The photos that I am about to show you are sometimes hard for the average person to interpret, hard for me. The painstaking work of photo analysis takes experts with

years and years of experience, poring for hours and hours over light tables. But as I show you these images, I will try to capture and explain what they mean, what they indicate, to our imagery specialists." The first photograph was dated November 10, 2002, just three months earlier, and years after the Iraqis were supposed to have rid themselves of all weapons of mass destruction. "Let me give you a closer look," Powell said as he flipped to a closeup of the first photograph. It showed a rectangular building, with a vehicle parked next to it. "Look at the image on the left. On the left is a closeup of one of the four chemical bunkers. The two arrows indicate the presence of sure signs that the bunkers are storing chemical munitions. The arrow at the top that says 'Security' points to a facility that is a signature item for this kind of bunker. Inside that facility are special guards and special equipment to monitor any leakage that might come out of the bunker." Then he moved to the vehicle next to the building. It was, he said, another signature item. "It's a decontamination vehicle in case something goes wrong. . . . It is moving around those four and it moves as needed to move as people are working in the different bunkers."

Powell's analysis assumed, of course, that you could tell from the picture what kind of truck it was. But pictures of trucks, taken from above, are not always as clear as we would like; sometimes trucks hauling oil tanks look just like trucks hauling Scud launchers, and, while a picture is a good start, if you really want to know what you're looking at you probably need more than a picture. I looked at the photographs with Patrick Eddington, who for many years was an imagery analyst with the C.I.A. Eddington examined them closely. "They're trying to say that those are decontamination vehicles," he told me. He had a photo up on his laptop, and he peered closer to get a better look. "But the resolution is sufficient for me to say that I don't think it is--and I don't see any other decontamination vehicles down there that I would recognize." The standard decontamination vehicle was a Soviet-made box-body van, Eddington said. This truck was too long. For a second opinion, Eddington recommended Ray

McGovern, a twenty-seven-year C.I.A. analyst, who had been one of George H. W. Bush's personal intelligence briefers when he was Vice-President. "If you're an expert, you can tell one hell of a lot from pictures like

this," McGovern said. He'd heard another interpretation. "I think," he said, "that it's a fire truck."

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