Photography

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At the time I was attracted to pure science – physics – where you could speculate and be creative. It's equivalent to being an artist. If you get the chance, and the cards fall right, there's no difference. The intellectual play and spirit are the same.

– David Byrne (interviewed by Timothy Leary), 2000

1 Mathematics

I have been a mathematician for as long as I can remember. Identified as talented early on, I was accelerated in school and sent to mathematics competitions. I entered university at the age of 15, specializing in "theoretical mathematics." At 20, I graduated with honours, finished the thesis that would become my first journal publication, and took up a junior academic position at the same university. At 23, I moved to Toronto to start graduate school there. I received my Ph.D. degree at 28 and held academic positions ever since, for almost 20 years. I have been fortunate to achieve a degree of recognition for my research. I am proud of the awards and honours I have received.

I am also all too aware of the popular stereotypes that a biography such as mine can evoke. Mathematicians themselves have done much to perpetuate the image of a single-minded genius, usually male, so dedicated to his pursuit of theorems as to place mathematics above everything else in his life and only grudgingly make concessions to other demands. Paul Halmos is one advocate of this school of thought:

What does it take to be [a mathematician]? I think I know the answer: you have to be born right, you must continually strive to become perfect, you must love mathematics more than anything else, you must work at it hard and without stop, and you must never give up. [...]

I do not mean that you must love it to the exclusion of family, religion, and the rest ... A spouse unsympathetic to mathematics demands equal time, a guilty parental conscience causes you to play catch with your boy Saturday afternoon instead of beating your head against the brick wall of that elusive problem – family, and religion, and money, comfort, pleasure, glory, and other calls of life, deep or trivial, exist for all of us to varying degrees, and I am not saying that mathematicians always ignore all of them. I am not saying that the love of mathematics is

more important than the love of other things. What I am saying is that to the extent that one's loves can be ordered, the greatest love of a mathematician (the way I would like to use the term) is mathematics. I have known many mathematicians, great and small, and I feel sure that what I am saying is true about them.

G.H. Hardy is another:

[I]t is undeniable that a gift for mathematics is one of the most specialized talents, and that mathematicians as a class are not particularly distinguished for general ability or versatility. If a man is in any sense a real mathematician, then it is a hundred to one that his mathematics will be far better than anything else he can do, and that he would be silly if he surrendered any decent opportunity of exercising his one talent in order to do undistinguished work in other fields. Such a sacrifice could be justified only by economic necessity or age. [...] It is very hard to find an instance of a first-rate mathematician who has abandoned mathematics and attained first-rate distinction in any other field.

Hardy, of course, also wrote famously that "mathematics [...] is a young man's game." I am a woman, and I am approaching the age past which, according to Hardy, mathematicians are no longer capable of great work. It has been pointed out correctly that the stereotype does not help the advancement of women, who are culturally expected to put family, not mathematics, before everything else in life, and who are more likely to experience career delays. My own dissent extends further. I feel that "the extent that one's loves can be ordered" can be so limited as to be meaningless in practice, and furthermore, that the extent to which one's loves can even be arranged as separate and distinct entities suitable for ordering is not always sufficient to make this line of considerations worth my while. Instead of using the blunt instrument of ranking one thing above others, I would rather query the complex relations and interdependencies between the many facets of who we are, with no *a priori* expectation that a winner must emerge.

Mathematical reasoning has always come naturally to me. I am taking a wider point of view here to include not only mathematics *per se*, but also the habits of mind that a mathematician develops: economy of thought, precision of expression, capacity for high-level abstraction, skill in balancing intuition against rigorous logic, ability to modularize and unravel complex arguments. Mathematics frames and nurtures particular ways of thinking, providing templates for them much like a language's grammatical structures. This is and always will be a part of me. It is constantly in the background, ready to come forward when necessary, whether I am engaged in mathematics or something entirely different altogether. I consider it one of my native languages.

I am also attracted to a type of artistic creativity I find in mathematics. Laypeople often associate mathematics with calculations, perhaps problem solving. Yet, mathematical research also has a world-building side to it. I would compare it to architecture, but with a twist, *Inception* style: we construct imaginary worlds, dreams within dreams within dreams, rooted in reality but increasingly abstracted from it. Each one must be internally consistent, but its rules may diverge from common real-life logic at some point. A topologist, for

example, might work with warped, multidimensional spaces, much like the dream-architect in *Inception* takes the city of Paris and folds it up on itself so that the building roofs touch each other. With such infrastructure at our disposal, when presented with a problem that resists a direct attack, we might go up several levels of abstraction, detour to a different imaginary universe seeking solution or inspiration, manipulate objects in one mathematical world to get the desired outcome in another.

There is a beauty to it. If mathematics is an art, it is not one that rewards passive consumption. Understanding a mathematical paper is like visualizing a building based on the architect's drawings: the text and formulas are only a blueprint that the reader must use to reconstruct the author's imaginary world in her mind. If she does that, however, then the best mathematical theories have the same breathtaking quality as the image of Paris folded on itself. The experience can be both exhilarating and addictive.

Contra Hardy, I am not nearly as attached to mathematics as a profession. My career could have forked in a different direction at any number of junctions; in a reversal of Hardy's sequence of priorities, it was in fact economic necessity and life circumstances that steered me back towards mathematics. I have always had other interests, other passions, and never felt that I should give up on them on the grounds that my talents were lacking in versatility.

Creativity and intellectual adventure will always be driving forces in my life. My professional occupation offers one outlet for them, but this is not to say that there are or could be no others. I have found that the same mental faculties could be applied in many different ways, that mathematical (in the broad sense) creativity is not so much in the nature of any particular pursuit as in the attitude that one brings to it. Not all mathematics is creative, and not all (again, broadly understood) mathematical thought is channeled through theorems, formulas and research papers.

Achievement need not be the ultimate measure of value. More specifically, I do not believe that we must focus on pursuing that in which we excel already. I do not even do this in mathematics. I have worked in a number of research areas now, and in each of them I was an unaccomplished beginner at first before I got better. Still, through building up connections between those areas, my work adds up to a greater whole than would have been possible for me if I had maintained a narrower focus. This is clearly not a universal *modus operandi* for all mathematicians, but it is the optimal one for me, as it is my nature to seek breadth and new challenge in all I do.

I have accomplished more in mathematical research than in anything else at this point. I take pride in my work. I also understand that time and energy are resources that must be prioritized with an eye on making a living. Yet, I would not want a life focused exclusively on mathematics. I do not consider it a "sacrifice" to pursue other passions when I could be working instead, to engage in something I enjoy without necessarily aiming for world-class excellence, or to wear a beginner's white belt over and over again in new settings. I consider it a life lived more fully.

2 Science

Photography can be deceptive. It does not appear to require much skill to point a camera at the scene and click the shutter release button. The obvious fact that some photographs

are better than others is easy to attribute to the quality of the equipment, or to good luck in finding the right object at the right time.

My own photography was purely functional for many years. I had a simple point-and-shoot film camera that I used on trips and at social events. I never attempted to develop the negatives, taking them to drugstores and photo shops instead. The random and inconsistent quality of the photos was a given. I was glad when they turned out well, but I also understood the difference between my amateurish travel snapshots and a professional photo album from the same location.

Artistic photography snuck up on me when I bought my first digital camera a few years ago. At first, the purchase was only a matter of convenience: skipping the trips to the drugstore, posting pictures to my webpage directly without having to scan them from prints. It soon became more than that. Once I had no reason, be it cost or hassle, to limit the number of pictures I took, I gave in to the impulse to play. Gradually, the utilitarian aspects took a back seat to the enjoyment of photography for its own sake.

As I started to pay more attention to the artistic and technical quality of my photos, I began to learn. My photography draws on any number of resources that I bring to it, from love of nature and familiarity with art history to mathematical style problem solving. We begin with the science of seeing.

The human eye does not work like a camera lens. It is, in fact, a rather poor optical instrument. The image that the light forms on the retina is at best fragmented and incomplete. The continuous, sharp picture we believe we see is the product of our brain instead, interpreting the signals, stacking and editing multiple images, completing the picture based on previously accumulated knowledge and educated guesswork. This is known as "unconscious inference," a term that goes back to Hermann von Helmholtz in the 19th century.

Exactly how it happens is not yet fully understood, but several theories have been proposed. Gestalt psychology suggests that we organize visual data according to patterns such as similarity, closure or continuity. We group similar objects together. We perceive geometric shapes (circles, triangles) as complete even when parts of them are missing. We choose to see them as continuous rather than broken, symmetrical rather than arbitrary. Well known optical illusions that corroborate the theory. Two lines are parallel, but look askew when additional lines have been drawn across them at an angle. A triangle not included in the picture is inferred from indentations in the shapes that surround it. M. C. Escher's paradoxical drawings invite the viewer to indulge her temptation to attach a familiar meaning to the visual stimuli, then turn the tables on her when an impossible object is revealed.

We classify visual input according to broad templates and interpret it based on probabilities. Often, we only take a quick glance at an object before we allow the part of our brain that handles sensory perception to go on autopilot. We expect a house to have a door, windows, a roof, so we take them for granted. Afterwards, we will be sure that we have seen them, but we will have no recollection of their shape or colour. On the other hand, unlikely or incongruent events tend to go unnoticed even when we believe that we are paying close attention. The Simons Lab at the University of Illinois at Urbana-Champaign has a series of mind-blowing videos demonstrating just how much visual information we can miss. People walk in and out of the room, objects get rearranged, one actor gets substituted for another in mid-action, and we remain oblivious to it all, never realizing that anything was out of order.

Researchers have examined and confirmed the notion that our perception of the world depends strongly on our relationship to it. In experiments, hills appear steeper when we are carrying a heavy backpack, and distances seem larger when we are cheated into perceiving our bodies as smaller.

It is one thing to be aware of the phenomenon in the abstract; it was quite another to find evidence of it in my own photography, in the discrepancies between my visual recollection of the subject and the actual image captured on camera, in the photos that did not turn out as expected because I had made lazy assumptions and did not bother to really look. I might, for instance, try to photograph a specific object like a bench in a garden, only to produce a chaotic image with that object all but lost in the background. Of course the bench would stand out to me. I had spent many an afternoon sitting on it and reading a book. The camera, however, is oblivious to my history with books and benches.

Conscious thought processes can mislead us further. We tend to think of rainclouds as dark and heavy, but they are in fact the source of light on overcast and rainy days; it is the rest of the scene that will appear darker by comparison. I have made that mistake more than once.

"Look with your eyes," Syrio Forel tells Arya Stark in *Game of Thrones*, and indeed when I do that, I see more. I cannot improve the optical parameters of my eyes. If anything, my eyesight will likely only get worse with age. What I can do, to the extent that I control the functioning of my brain, is train it to forego the mental shortcuts and focus on the acquisition and processing of the actual received image. I have been cultivating the habit and have gained some proficiency at it.

There are exercises, best practices, small things I can do. I might stay still for a long time, watching the scene quietly and absorbing the details until a few begin to stand out: the shadowplay on a well formed leaf, a blade of grass that bends just so. Other times, I might walk around and engage physically with the scene, turning this way and that to find the best light and angle, stopping to look up to the treetops, bending down to check under the leaves. I might bring along the "wrong" kind of lens on purpose in order to force myself to go past the obvious and look harder, for example shooting landscapes with the macro lens. It all goes a long way towards improving my photography, from an often random process to more control and awareness.

3 Art

What should a photograph capture? In light of the above, there is no reason for the answer to be obvious. Should we target the objective truth, whatever that might be, or aim for images that are beautiful and attractive? Should we maximize the amount of information included, try to capture the mood, account for our own feelings? Should we try to make the hill look steeper depending on the weight of our backpack?

Would an unedited image shot on automatic settings be "natural"? Consider for instance what happens when some parts of the scene are much brighter than others. Our eyes compensate for this, adjusting the aperture constantly by dilating and shrinking the pupils, so that we see the details of both the bright and the dark objects. In photography, though, the aperture is fixed. To mimic the way we process the scene in real life, the photographer

might edit the image or blend several exposures. She might also, however, leave the photo unedited, with parts of the scene underexposed. That could still be a fine image, but it would not necessarily look more natural to us than the edited one.

We do not look at a photograph the same way that we look at its subject. Take landscapes. In real life, we explore them gradually as the eye wanders from one object to the next one, changing focus, taking the time to cross the spaces between them. All of this can be lost in a small two-dimensional image. It is too easy to throw a mass of details at the viewer with no hierarchy, order, or separation between them, each one equally important and shouting for attention. Good photography establishes and explores visual relations, restoring the order and the empty spaces that would otherwise collapse in the loss of a dimension. It does so through the tools of art: framing, composition, light, focus, colours, contrast.

There is nothing new about this. It is all but forgotten today that early photography, in the nineteenth century, aimed explicitly to imitate paintings. This was done through composing images carefully, adjusting focus and exposure, manipulation of colour and contrast in developing the negatives. Long before the invention of Photoshop, photographs were being airbrushed and had details sketched into them. Multiple negatives were combined into one photograph, often through literal cutting and pasting. Edward Steichen, often considered to be the first fashion photographer in history, wrote in 1903:

> *In the very beginning, when the operator controls and regulates his time of exposure, when in dark-room the developer is mixed for detail, breadth, flatness or contrast, faking has been resorted to. In fact, every photograph is a fake from start to finish, a purely impersonal, unmanipulated photograph being practically impossible. When all is said, it still remains entirely a matter of degree and ability.*

Artistic creativity and vision are forced on us when we try to simply depict the world as it is and discover that this, in fact, is generally not possible. Any rendering of the view before us as a photograph is a format conversion that calls for artistic choices.

This leads to a problem-solving process, one that I find very similar to what I do in mathematics. (I am hardly the first to observe this. Just last year, I attended a talk by a painter I admire who spoke of his work in terms of "solving the mathematical equation.") In my research, I try to understand the problem at hand in a very specific, dynamic way. I need to know how it works: what are the relations between the components? What are the dependencies? How does the rest of the picture change if I tweak this part? Is this part necessary? How can it be replaced? It is common to look at the problem from different directions, translate it into a different language, convert it to another format. My mental activity when taking and processing photographs mirrors essentially the same templates.

A small example might illustrate what I have in mind. The photo at the top of this section shows the view from Reef Bay, Mayne Island, with Mount Baker in the background. Mount Baker is about 110 km from Reef Bay in a straight line. It looks like a mirage, as it probably should (according to my back-of-the-envelope calculations, it could in principle be seen from that far, but should not be as prominent as it is without additional optical effects). In photographs, it is often just barely visible, a vague outline blending into the background; nonetheless, for someone there in person, it attracts attention to the point of dominating the landscape. How can I get that on camera?

The first point is that the photographs are probably true to the actual optical reality. Our own in-person perception is far more subjective; if our attention centres on Mount Baker, this is likely because we are so eager to place it there. The second point is, how to induce a similar effect in a photograph? This is where the knowledge of Gestalt theories, optical illusions and similar tricks can come in handy. In this particular case, the bleached drift logs by the entrance to the beach provided what I needed. With the two whitish objects near the bottom of the image, the viewer would look for a third one higher up as a counterpoint, and sure enough he would find it.

Many photography books and websites list so-called "rules of composition." The rule of thirds, for instance, is to divide the photo frame in thirds and position the points of interest on the dividing lines. There are rules on using leading lines, geometric shapes, repetitions, grouping similar objects together, organizing them according to patterns. The connection to Gestalt theories is unmistakable, although the same rules were already evident in the practice of painters and visual artists long before the term "Gestalt psychology" was first coined.

It is very unlikely that following these rules could, by itself, make anyone a good photographer. To fall back on a mathematical comparison again, mechanical textbook recipes are no substitutes for a genuine understanding of the underlying theory. The former are useful to a point, but it is only the latter that allows problem solving on a higher level. Similarly, good photography requires actual intellectual and emotional engagement with the subject rather than cheap prescriptivism. The rules are only a toolkit. They offer little help to a beginner who, like a confused calculus student, is not sure which one to use. That knowledge comes over time, through practice, experience, analysis, trial and error, much as it does in mathematics.

4 Craft

I have always needed art in my daily life, much as I need fresh air and sunlight. I look for it wherever it can manifest itself, from galleries large and small to artisan craftwork, paintings in coffee shops, street graffiti or tattoo designs.

I grew up believing that art was something that I could admire but should not attempt. Artists were more than mere human beings. They possessed talent and skills I did not have, were gifted with inspiration and insight I could not hope for. Craft, however, was something I could wrap my head around. Instead of grand visions, it started with simple necessity. People needed clothes, linens or house decorations, so they made them. Along the way, they might choose to pay attention to the designs, which would then evolve in complexity and difficulty as the skills of the makers continued to grow.

It was only in my adult years that I came to think of art and craft as parts of one continuum. Ancient Greek pottery or medieval miniature paintings were the crafts of their times, yet we now regard them as art. Craft can be a starting point for an artist who goes on to transcend it, or it can be an end in itself, enriching lives and providing a lifetime of satisfaction in work well done. The difference is one of degree and not kind, the boundary fluid and malleable.

My appreciation for handicraft, for small-scale artistic creativity in everyday life, is due

in part to my upbringing in the then-socialist Poland. It is customary in Western culture to depict the lands beyond the Iron Curtain as drab and grey, and their consumer goods, from clothes to home furnishings, as plain and unattractive. While this is true to a large extent, it fails to account for home industry. Sewing, knitting, crocheting and embroidery were all commonplace. Fashion-conscious women sewed their own clothes, made alterations, combined accessories in thoughtful and creative ways. Unusual coffee tables and shelves could be made from reclaimed boards or crates. Heritage items were altered, reused and repurposed many times over. The life I knew allowed far more room for individual expression than one might guess from old photos of store window displays.

I could crochet reasonably well. I was minimally competent at sewing, embroidering, and woodworking, and I never learned to knit. My artwork in school did not draw accolades, either. What stayed with me nonetheless was the need for creative expression in everyday life, the do-it-yourself attitude now seen in the maker culture, the belief that skills can be learned as needed.

The protagonist of *Wall-E* comes to mind: a little robot cleaning up the trash on a future Earth long since deserted by humanity, an unglamorous and thankless job if there ever was one. What humanizes him is his appreciation of art and beauty. His home is full of little toys and trinkets rescued from garbage, adorned lovingly with discarded home furnishings and brightened up by strings of Christmas lights. An old television set plays "Hello Dolly" on a loop as Wall-E recharges and relaxes. These images brought back so many memories of the dorm rooms and bachelor apartments from my student days, right down to the Christmas lights used year-round.

This is a digression, but a necessary one if I am to explain why I take photographs. They are my "acceptable decorations," as Leonard Cohen writes of his paintings. It makes no difference whether they are as good as my mathematics, or whether someone like Hardy might call them undistinguished. What matters is the sensory deprivation I feel in the absence of art. I do it for the thrill of shooting and editing images, for the pleasure of having them around as I go about my affairs. I find it immensely satisfying when others enjoy my work, but if they did not, I would do it anyway, for myself. I would do it because that is what I do and who I am.

5 Nature

I fell in love with the Pacific Northwest 20 years ago, on my first visit to Vancouver. The scenery rendered me speechless. I could not get enough of the wide ocean vistas, the steep mountains and islands rising from the sea, the majestic forests. I could almost feel the pulse of a nature barely constrained, bursting through the city's seams and threatening to swallow it whole. I swore I would be back one day.

I have lived in Vancouver for 13 years as of this writing. The line between the city and the wilderness is indeed thin and porous. A coyote might stroll down a residential street at night, or prowl a neatly manicured garden in plain daylight. Bald eagles nest in parks in the middle of the city. Just last year, a black bear was found in a garbage container downtown between the office towers, and this summer a whale was seen in the city harbour. I leave my office on campus and walk about one city block to a viewpoint, and I am looking upon the

mountain ranges across Howe Sound, mostly uninhabited and as inaccessible as ever. Save for the lonely Highway 99 and its attendant towns, a wide swath of land north of the city comprises only mountains, forests, lakes and glaciers. As urban as Vancouver is, it never lets us forget how close we are to the frontier.

When we love something, we have a strong desire to talk about it. I took to photography as a high school student might take to writing poems about her first romantic crush, eagerly and naively. I needed to capture the magical sunsets on the beaches of Gulf Islands, the sandstone rocks sculpted into fantastical shapes by the waves and the wind, the sea otters playing on a kelp bed, the explosion of flowers in Vancouver gardens in the spring. It did not matter that I only had a very basic camera and a minimum of skills when I started. That was beside the point.

Talking means little without listening, though. Love needs to grow and evolve past adolescence, informed by actual knowledge and understanding of the subject. In nature photography, this starts with basics: knowing what grows where, when it blooms, where and when to look for blue herons or eagles, what light to expect at different times of day. One can go much further than that, much deeper. Better artists than myself have dedicated their entire lifetimes to studying the Pacific Northwest. I am, and probably always will be, far from an expert. Still, even the smallest bits contribute to making my photography better. For every good capture due to pure luck, there are many more where my luck was aided by knowing where to go and when to have my camera ready.

British Columbia boasts an amazing diversity of landscapes and ecosystems. The coast has steep cliffs and dense rainforests, but also the farmlands of the Fraser River delta and the long sandy beaches of eastern Vancouver Island. The Gulf Islands, partially sheltered from the rain by the Vancouver Island mountain ranges, enjoy an almost Mediterranean climate in the summer. In the Okanagan, orchards and vineyards nest in lakeside valleys surrounded by arid, semi-desert hills. As one drives further north towards Williams Lake, the dry landscape gives way to the northern glacial lakes and forest flatlands of the Caribou.

In 2012, I drove to Port Hardy on the northern tip of Vancouver Island, then took the Inside Passage ferry to Prince Rupert, just south of the Alaska panhandle. The Inside Passage is a 500-km waterway winding through a maze of channels and islands just off the coast, flanked on both sides by mountains rising hundreds of feet straight up from the ocean. Most of its length passes through uninhabited territory except for the occasional lighthouse or logging operation. A guided tour out of Prince Rupert offered opportunities to photograph bald eagles and grizzly bears.

There is so much more to see. Even so, I find it preferable to explore slowly, return to the same places multiple times, spend some time, get to know them in some depth. This works better for my photography as well. On my first visit to a location, especially if it is a brief one, I often only collect the low hanging fruit of postcard-style shots, pretty but conventional, sometimes clichéd. There is nothing wrong with that. Clichés and conventions gain ground for a reason. Yet, if I stay for a few hours, my perceptions can change. No longer focused on the first impressions, I start noticing more details and thinking of more possibilities. The photographs I take on my second and subsequent visits are better still. Part of it is that, knowing what to expect, I can bring the right equipment, read up on a shooting technique I might need, or plan to come at a specific time of day when the light is optimal. I am also better prepared mentally, having bounced the images around my brain

and analyzed them (consciously or not) in the problem-solving way I have described.

Each type of photos has its own challenges. Rainforests, for instance, can be stunningly beautiful but very difficult to shoot. A photograph needs light, but the rainforest offers very little of it, the dense canopy blocking out the sky. When the sunlight comes through, it does so in sharp bursts, blinding us and the camera to the rest of the image. We seek order and restraint in pictures, but the rainforest is the opposite of both, a chaotic jumble where all manners of vegetation – trees, ferns, moss, shrubs, fungi – pile up on top of each other, all linked together and growing to the limit of their capacity. So far, I have had best results when I focused on a small part of it: a single tree trunk covered with moss, a well lit branch, a sapling nested in the shadow of an old stump.

Macro photography (magnified close-ups of small objects such as leaves, flowers or insects) is perhaps the most personal for me. One part of it is the feeling of intimacy engendered by the close proximity to the object while shooting; another is the creative freedom that this type of photography allows. In showing microscopic details invisible to the naked eye, the image breaks the sense of reality and creates a suspension of disbelief. A magnified part of a leaf or tree bark loses the connection to the original object, becoming an abstract burst of light, colour or pattern. Objects in the background shift and blur to the point of being unrecognizable. There is ample room for editing and manipulation. The resulting image can be intensely subjective, depending as much on the photographer's vision as on the object being photographed.

6 Tools of the trade

The tools of digital photography are computers and high-tech digital equipment. It is not necessarily what I would have planned for. Had it been a more conscious decision, for instance if I had been asked to pick a technique before signing up for art classes, I might have chosen watercolours, oil on canvas, charcoal – something more hands-on, closer to a traditional craft, something that would keep me away from the computer instead of adding more desktop time. But that was not how it happened, so digital cameras it is.

For the reader less familiar with digital photography, I should explain that there are essentially two types of digital cameras: EVF (electronic viewfinder) and digital single lens reflex (DSLR). The main difference is in the optical mechanism. A DSLR camera uses a mirror positioned behind the lens to reflect light towards the viewfinder, then swings it away momentarily when the photo is being taken, exposing the sensor behind it. Compared to EVF compacts, a DSLR is a much better optical and electronic instrument. The more robust optical mechanism delivers a better quality image for the capture: the contours are sharper, the colours truer, the angles less distorted. The photographer has better control of the image and more creative freedom to manipulate it through focus and aperture (choosing which parts of the image will be sharp or blurry), exposure time, white balance, colour tone and intensity. Additionally, most DSLRs are equipped with large electronic sensors capable of recording more detail than those found in typical compact cameras, even when the nominal image resolution is the same.

As of this writing, I own an entry-level DSLR with several lenses as well as a higher-end point-and-shoot compact camera. The DSLR is the best camera I have had so far. At

purchase, it only came with a general purpose 18-55 mm lens. I have taken many photos with that lens that I quite like, but its limitations became apparent soon enough: it cannot zoom in closely enough on distant objects, nor is it wide enough for panoramic landscapes, nor is the aperture low enough for common low light situations. I have since upgraded it and bought additional telephoto and macro lenses. (Serious photographers have many more.) A few accessories can extend the camera's functionality. For low light scenes, long exposure times or close-ups of faraway objects, a tripod is necessary to keep the camera from shaking. Filters and lens hoods allow better control of the light.

This is where I will stop for now. Almost any DSLR camera today, including the model I own, is capable of producing professional quality images when used with some competence. Should I run up against its limitations, for instance if I ever take up more specialized photography with particular technical demands (such as sports or wildlife photography where the ability to take sequences of shots in rapid succession is crucial), I will consider upgrading the gear accordingly. In the meantime, I have ample room to grow as a photographer with the equipment I own already.

I have no plans to part with the point-and-shoot, either. As photography became a habit and an extension of my senses, I took to carrying a camera with me at all times, and the DSLR is too bulky for that. Additionally, I need a travel camera that I can take along even when I travel light. The one I have is good enough that I often think of it as different rather than inferior, like crayons compared to oil paint. The effective resolution is lower. The camera is less versatile, less reliable in technically demanding situation, and not well suited to images that rely on depth of field, subtle colour shifts or light effects. When it comes, however, to high contrast images in bright light, with all objects in the frame essentially sharp, the performance is consistently excellent.

There are purists who insist on shooting only on manual settings. I do not find it necessary. Most of the time, I only need to be able to control some functions, especially aperture (for depth of field) and shutter speed when shooting moving objects (for focus). Both are important and cannot be changed in post-processing. I like to use semi-auto settings that allow me to set these manually while keeping everything else on automatic. I also shoot RAW images whenever possible (unfortunately, the compact camera does not support that). These are large files containing the unprocessed data projected on the camera sensor; they must be uploaded to a computer, processed there, and eventually converted to JPEG or other common image files. In the processing, there are opportunities to adjust the white balance, sharpness, contrast, colour tone and intensity, and more. While much of this can also be done at the time of shooting using appropriate camera settings, I would rather do it afterwards, for two reasons: it allows me to concentrate on the image while shooting, rather than on clicking through menus, and it lets me see the results of my manipulations before I save the image.

I have no qualms about editing my photos. It is a necessary step in any case when working with RAW images, no matter one's philosophy or preferences. Making corrections such as trimming and straightening out the image, or erasing dust spots, is not cheating; it is a courtesy to the viewer. This does not mean that skill with camera is no longer needed. The optical input from the lens is still the basis for any further work, and a poor image cannot usually be fixed by heavy photoshopping. A good photograph, on the other hand, can be improved significantly by even small edits.

Above all, photography is not all about the gear. Personally, I find a good pair of boots for walking through mud or wet leaves far more important than the latest gadget du jour. Long exposure photography is best done with a tripod, but I have also used rocks and ledges in a pinch, with the camera on a timer so that pressing the shutter button would not shake it during exposure. Were I to insist on matching the equipment perfectly to every shooting situation, I would not be taking many photos. I have indulged myself on occasion and have no regrets about that (the macro lens was expensive but worth it), but mostly I make do with what I have and improvise as needed.

7 Language

Art begins as a solitary endeavour, a physical expression of the artist's internal life. It ends as a means of communication.

I learned the language of visual arts by immersion. I grew up in Legnica and Wrocław, two Silesian cities with a rich artistic and architectural history. Old paintings, historic buildings, castles and churches were a constant part of my life. I walked past them daily on my way back from school. My father was an architect with a keen interest in visual arts, and I had unrestricted access to the art catalogues and albums around the house. I had much of the canon of Western painting, sculpture and architecture, with its vast store of templates and points of reference, imprinted on me by the end of my teenage years.

I have since come to love the Canadian canon: Maurice Cullen, Emily Carr, Tom Thomson, the Group of Seven. I was drawn to the West Coast art, from Carr and Jack Shadbolt – icons here in Canada, less known elsewhere – to the thriving local art communities, the majesty and discipline of traditional Haida artwork, the stunning contemporary First Nations art by innovators like Lawrence Paul Yuxweluptun. I have also spent almost half of my life living in cities with significant East Asian minorities, and that has rubbed off on me as well.

All this background gave me a significant advantage in photography. Composition came naturally. Effects involving light and focus took longer, mainly because there were technical skills I needed to learn. I often know a good image when I see one, or can imagine ways to make it better, instantly and without much thought. It was never a matter of imitating any specific painting or style directly; I would not presume to have the ability or, in the case of Native artwork, the right. Rather, having acquired a certain vocabulary and grammar, I took to using parts of it to build new sentences and tell my own stories.

I started posting photos on my blog as soon as I bought my first digital camera. I did not attach much importance to it. They were a visual distraction, something lighter to alternate with the more substantial posts. I did not expect or seek feedback on them, but started getting it nonetheless, and responded to it. There is something incredibly exciting about having an audience and engaging in a dialogue with them. It does not have to be a large following. The qualitative transition happens much earlier, in the realization that our work can appeal at all to people we might not know, that they might even remember it and take the time to come back for more.

In the age of the internet, no artist with access to it need be alone. I soon started reading, posting and commenting in online photography communities. There are many of them, large

and small, public and private. The quality of photos is often very high. Equally important is the community aspect: people listen, pay attention, respond, compare experiences and offer advice. There is an ongoing conversation where we do not just talk *about* art, but also *through* it. Ideas are shared and examined from different angles, not just in words, but through photographs that express them. There are groups and pages for photos with a common theme: macro photography, flowers, trees, self-portraits, street photography. I have experienced the joy of discovering like-minded photographers, the excitement of reaching out to them and drawing creative energy from the interaction.

To no great surprise, I found that I still have much to learn. Yet I am encouraged by the feedback I get, by hearing from others further along the way about their learning process. I enjoy the dialogue, even if my grammar is still clunky and I am lost for words sometimes.

8 Beauty

> *The mathematician's patterns, like the painter's or the poet's must be* beautiful; *the ideas like the colours or the words, must fit together in a harmonious way. Beauty is the first test: there is no permanent place in the world for ugly mathematics.*
>
> – G.H. Hardy, *A Mathematician's Apology*

> *The best way for an emotion to occur in art is the way it occurs in the rest of life. One does not live to have emotions, but one lives and has emotions.*
>
> – Bertolt Brecht, *Critique of Empathy*, translated by Todd Cronan

To paraphrase Brecht, beauty occurs in mathematics as it does in life: neither by premeditation nor entirely within our control, but not by an accident removed from our actions, either. Mathematics, first and foremost, has to accomplish its stated purpose. A proof must be correct and complete, a theorem should say something relevant to the work of other practitioners. It is only afterwards that we can afford to look back and reflect on the aesthetics of our creation. When we do find beauty in mathematics, it is often reminiscent of nature, where function precedes and defines form. Birds, trees, or flowers evolved the way they did with a view to functionality and survival, not to pleasing our eye.

This particular comparison is inspired by Antoni Gaudí, the Catalan architect best known for the still-unfinished Sagrada Familia church in Barcelona. Gaudí drew on both biology and mathematics in his work, integrating their elements into his designs in an organic manner. In his quest for architectural solutions that were both structurally and aesthetically desirable, he turned to forms found in nature: bones, skeletons, reeds, shells, tree trunks and branches. This led to his use of ruled surfaces including paraboloids, hyperboloids and cones, fractal shapes, quadratic and catenary curves. All of these are also well known mathematical objects, their equations elucidating the same structural properties that make them the preferred choices for both Gaudí's constructions and living organisms in nature.

As a mathematician, I sometimes have books or artwork recommended to me based on their mathematical themes: a character who is studying mathematics, a sculpture representing a geometric construction, a painting whose composition is based on some numerical

scheme. The expectation is that I will find this attractive. In reality, I have no desire to view everything in life through the same narrow glass. There are no bonus points for name-checking a math equation. I want art to speak to me as art, on its own terms. Gaudí's work, stunning in its richness and complexity, does just that; the mathematics in it is a logical consequence, not an empty adornment.

The beauty of mathematics, as I see it, is intellectual, multilayered and demanding. It is earned and experienced through active engagement. Attempting to convey it through gratuitous emotion by way of art puts the cart before the horse. This is not to say that the joy of mathematical thinking, broadly understood, is absent from art. I find it in artwork that values complexity, challenges me intellectually, perhaps draws me into the creative process. Escher prints would fall into that category, as would many works of art with no explicit connection to mathematics. At the same time, I often see mathematically-themed art that is purely decorative: tilings, fractal patterns, arrangements of geometric figures. There is nothing wrong with that, I enjoy decorative art as much as anyone else. Such art, however, says very little about mathematics and nothing at all about the ways and reasons I find it beautiful.

I have never tried mathematically themed photography, nor do I wish to use my photography as an excuse to evangelize on behalf of mathematics. I never even felt the attraction. Instead, it is love of art and nature that drives my photography. My creative process is "mathematical" in the sense that my brain operates in much the same ways as it does in my research, but in the finished product, my visual language must first and foremost match my subject and my perception of it. Beauty, emotion, mindfulness of my theme are the primary considerations; my profession is beside the point.

Mathematics occurs in my photography the way it does in life. If I frame the image so as to arrange the objects in focus in a geometric shape, as Gestalt theories suggest, it is to establish some order in the picture, not to send the viewer searching for a calculus book. If I photograph a leaf, it is not because the striations remind me of foliations in topology. The similarity is in fact very real. There are structural reasons why leaves are built in this particular way, and there are also reasons why mathematics would take an interest in such structures. What draws me as a photographer, though, is the way that light illuminates the spaces between the veins as it seeps through them, leaving shadows along the curves of the edges.

Between mathematics and art, I do not need one to justify or explain the other. I pursue each to its own ends and I follow where they take me.