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PERSPECTIVE

The art of observation: bridging science and art to see the unexpected

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ABSTRACT

Observation is the heart of research, but it can be challenging to observe deeply and go beyond expected observations. Here, we describe activities designed for scientists to enhance their observational skills by engaging with art. In collaboration with an art gallery at our university, our lab practiced observing representational paintings in a systematic way, separating the act of observation from interpretation. Applying this skill to our microscopy images allowed us to access information in the data that may otherwise have been overlooked. In addition, these activities highlighted the power of collecting observations from multiple observers before generating interpretations, as well as the value of discussing the creative and emotional aspects of data collection and interpretation. We provide concrete examples of how we will incorporate these skills into our research processes, as well as details that other groups can use to engage in similar art-based training activities to enhance their own observational skills.

The challenge of observing deeply under increasing external pressures

Every iteration of the scientific process boils down to this: making observations, interpreting and integrating observations, and communicating observations to others. Yet the biology that we seek to observe contains more complexity than we could ever capture in our data and models. Even when we attempt to grasp that complexity with increasingly sophisticated technologies and analytical approaches, ever-looming deadlines, the increasing bar of what a 'complete' scientific story looks like, and the natural human desire for simplicity can tempt us into looking for singular, straightforward conclusions within our data. We can also feel pressured to move on quickly to the next dataset or analysis after finding that one straightforward conclusion, or after struggling and not finding any conclusion at all. This cycle results in collections of data that have only been superficially explored, and that contain answers to many more questions than we have yet asked. Analyzing these datasets and approaching a fuller understanding of biology requires systematic approaches, ample time, and a balance between the desire for simplicity and an appreciation of complexity.

In the Greco lab, we access the complexity of biology through visual information – colors and shapes and cellular movements under the microscope. Specifically, we use intravital imaging to understand the properties and behaviors of cells and tissues in the skin of living mice. The images and movies we produce are rich with information, and have allowed us to discover phenomena we had not imagined before doing the experiments, such as cells pushing out, eating up or actively coordinating with their neighbors (Greco, 2016). Discoveries such as these have only been possible when we have really *lingered* with our data, giving ourselves time to notice the unexpected, and remaining willing to dismantle our initial interpretations. In our experience, this approach leads to the most impactful results and the most fulfilling research process. We try to nurture this approach with regular 'big-picture' brainstorming sessions and comprehensive six-month data reviews. In 2023, inspired by the ways art has impacted our colleagues in the clinic, we experimented with a new approach: connecting with one of our university's art galleries to learn new ways of overcoming our preconceptions and exploring our data deeply.

Using art to enhance observational skills

In the late 1990s, Linda K. Friedlaender, Head of Education at the Yale Center for British Art, and Dr Irwin Braverman, Emeritus Professor of Dermatology at the Yale School of Medicine, developed an art-based program using representational paintings to enhance medical students' ability to see visual details (Friedlaender and Friedlaender, 2013; Dolev et al., 2001). In this program, students learn observation by cataloguing the constituent parts in a painting and resisting premature interpretations. Linda and others have found that this systematic practice of slowing down to focus on observation before coming to conclusions is particularly important for healthcare practitioners, who are continually integrating explicit and implicit information about patients to quickly identify the 'correct answer' about what their patients need. 'Enhancing Observational Skills' is now a required class session for all Yale medical students, and similar programs have been adopted by dozens of medical and nursing schools around the globe (Perry et al., 2011).

When our lab learned about this program, it struck a chord with the need for careful, open-minded observation in our work with microscopy images. We connected with Linda and, over several months, we designed a version of the 'Enhancing Observational Skills' workshop and follow-up activities involving paintings and our own microscopy images (Box 1). The goal was to use unfamiliar art-based objects to learn how to explore microscopy data beyond expected patterns and initial answers. As Jennifer L. Roberts puts it in her article, 'The Power of Patience' (Roberts, 2013): 'just because you have *looked* at something does not mean you have *seen* it'. We hoped to get closer to truly *seeing* the biology in our own data.

Bringing the lab to the art gallery

One morning in early May 2023, our lab spent two hours with Linda at the Yale Art Gallery. Getting out of our lab space was crucial to stepping out of our comfort zone. We found ourselves surrounded by

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Box 1. Bringing the lab to the art gallery

Preparation

- Linda visited the Greco lab to learn about our microscopy images and how we use them.
- Lauren, Haoyang and Valentina visited the art gallery to test-run the activity.
- Lab members read Jennifer L. Roberts' article 'The Power of Patience' (Roberts, 2013), which describes one art historian's efforts to teach her students how to immerse themselves in a piece of art to unlock subtle connections and deeper meaning.
- Lab members submitted a single 2D image that intrigues them in some way (e.g. they found it beautiful or they struggled with, or were curious about, something in it).
- Linda, Lauren, Haoyang and Valentina chose five of the microscopy images for the group activity, prioritizing those of 'medium complexity to describe'.

On the day

- Linda provided a brief overview of her 'Enhancing Observational Skills' program (5 min).
- The group silently observed John Constable's 'Stratford Mill' painting (Fig. 1). Linda instructed us to walk around, looking at the painting from different distances and angles. She encouraged us to sketch shapes we saw in the painting (10 min).
- The group discussed what we observed in 'Stratford Mill', first describing objects only in terms of colors, shapes and physical relationships, then articulating interpretations about the identity of objects and what they were doing, and finally creating a narrative based on our observations and historical context provided by Linda (30 min).
- The group repeated this practice with another painting, Francis Bacon's *Study of a Head* (15 min).
- The group discussed five of the pre-submitted Greco lab microscopy images in small groups (each group excluding the person who had submitted that image), describing the images in terms of colors and shapes (45 min).

soft-lit artworks and the quiet murmuring of fellow museum visitors, as opposed to the usual fluorescent-lit bays and the relentless hum of lab machines. Linda immediately took us to sit in front of John Constable's 'Stratford Mill' study (Fig. 1) before giving us a brief overview of the 'Enhancing Observational Skills' class she teaches to medical students. She then instructed us to spend ten minutes silently observing the painting. We were given minimal instructions on how to do this, except that we should try looking at the painting from different perspectives (far away and close up, from the left side and from the right, squinting or with a tilted head), and we were encouraged to roughly sketch what we saw on provided paper. After about ten minutes of silent observation, each of us separately orbiting the painting, we sat back down to describe our observations verbally. For many of us, this is where the challenge began. Linda pushed us to describe the shapes, colors and relative positions of objects in the painting in as much detail as we could *before* articulating any interpretations or even naming objects directly. For example, instead of saying, 'there is a man fishing', we might say, 'there is a figure in the lower-center of the painting with a red fabric near their neck or back, facing mostly away from us, holding a long, thin object that projects in front of them and towards the blue-gray region of the painting'. Any time we slipped up – stating an interpretation or pointing at the object rather than describing it – she re-directed our words. She also prompted us to see some of the techniques Constable had used to draw attention to different features of the painting, such as distributing pops of red throughout an otherwise mostly green, blue and brown image to move the viewer's eyes across the painting and towards specific figures. Each lab member contributed at least one observation of the painting, and this mode of description seemed to become easier over time.

Fig. 1. John Constable's 'Stratford Mill' (1819-1820) at the Yale Center for British Art.

After about 25 minutes of collectively describing the painting in this way, drawing out as many of these abstract observations as we could, Linda invited us to begin articulating the story we perceived in the painting. The simplest version of that story was a group of country-dwellers on the banks of a river, some fishing or doing laundry or just relaxing. However, different people saw subtly different versions of the story (Was a storm coming in or leaving? Were those horses or cows in the background?). These different stories often stemmed from very subtle aspects of the painting – things that we would not have noticed if we had spent less time with the painting. Finally, by giving us additional historical context, Linda helped us to see that this painting was one of John Constable's attempts to romanticize the English countryside of his youth while Britain was rapidly industrializing. Hearing this context colored our group's story of the painting and, even more importantly, began to reveal how our own expectations and cultural context colored the observations and interpretations we arrived at.

Linda's lesson can be extrapolated into a three-part process: (1) individually making observations, (2) collectively describing our observations without opinions or interpretations, and (3) collectively building a narrative within the painting based on our observations and contextual information. Crucially, we learned to separate the initial observation from the eventual interpretation (i.e. adding time between each step). Preliminary observations constrain what we can observe (Yanai and Lercher, 2021, 2020; Koehler, 1993). Although this constraining effect can sometimes lead us in a productive direction (e.g. presenting new questions to ask about the data), it can also prevent us from seeing things in the data that do not neatly fit the initial interpretation. Being able to recognize and separate observation from interpretation can give us control over when we are closing the door to more observations, and when we are opening that door.

Our activity also reinforced the power of observing and interpreting as a collective group. Each person brings a different perspective, augmenting our capacity to observe and to understand the painting with more depth. Importantly, no one in our group had any expertise in art, let alone John Constable's paintings from the early 19th century, but we were all able to speak about shapes and colors. As a result, each observation or interpretation was voiced and considered with equal weight, and all the observations together formed our group's collective story about the painting. This feature resonated with our group's commitment to team-based science and

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Box 2. Bringing an artistic lens to the lab retreat

Preparation

- In the three months between the gallery experience and our lab retreat, Lauren collected feedback and ideas from the lab about how to continue exploring their microscopy images with an artistic lens. One recurring idea was to explore how we can see more in our images by manipulating them (something we commonly do in our research processes).
- Each lab member submitted a 2D multicolored image, replicated four times with some combination of the following modifications: cropping, altering colors in one or all channels, representing only one channel in grayscale, rotating or filtering the image, or masking colors. We refer to these as 'Microscopy Pop Art' (Fig. 3).
- One microscopy image, from a lab member not attending the retreat, was printed on a two-by-four foot poster board.

On the day

- The one large-print microscopy image was mounted, evoking a gallery exhibit. Mirroring Linda's procedure in the art gallery, Lauren instructed the group to observe the painting silently (walking around, observing from different angles, sketching, etc.) (10 min).
- The group discussed their observations from this image (20 min).
- Pairs of lab members discussed their Microscopy Pop Art. Pairs swapped images, silently observed them and then described them to one another (30 min).
  - Observers considered the following questions: Do the different versions of the image reveal different things? What questions arise based on this image? Does the image remind you of anything?
  - After the observer described what they saw and answered the questions, the artist explained what the image was, and why they had made those specific modifications.
  - The observer and artist together discussed the following question: What biological questions arise based on these two images?
- The whole lab reunited for a discussion about how this activity might extend into their day-to-day research processes.

our frequent conversations about the need to welcome more voices into the scientific process, themes which we continued to explore in subsequent activities.

Deconstructing microscopy images individually and in community

After practicing this deep observational approach in the art gallery, we applied it to microscopy images from our lab. Lab members were asked, first, to individually *observe* objects in the image, then to *describe* their observations in an abstract manner, and finally to collectively integrate the observations together with known contextual information to *interpret* what the image contained. We practiced this in two stages: in small groups immediately after the gallery experience (Box 1), and in pairs at the lab retreat two months later (Box 2). In both cases, lab members were asked to prepare images from their own data that stuck out to them in some way (e.g. they found the data beautiful or ugly, or they were proud of those data). We wanted to see whether we could observe anything new in our microscopy images using the observational approach Linda had taught us, and to develop concrete strategies for integrating this observational mindset into our daily research practices.

In some ways, describing our own images of mouse skin cells in terms of colors and shapes was even more challenging than it had been with Constable's painting. For example, rather than describing an epidermal stem cell layer interspersed with collagen bundles and hair follicles, we described interconnected cyan polygons blending into seemingly tangled white fibers surrounding distinct circular arrangements of the cyan polygons

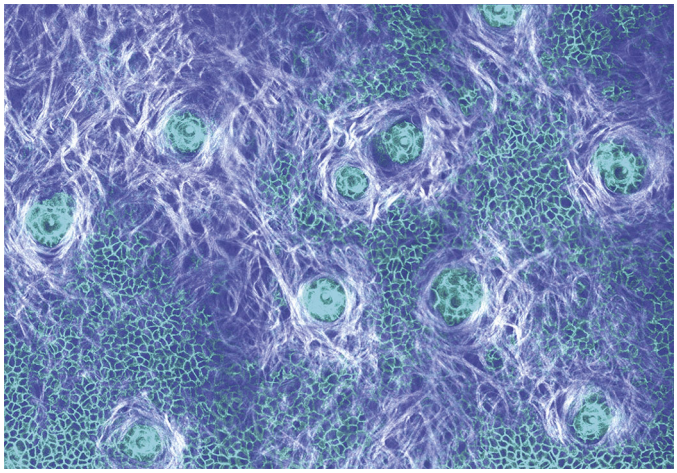

Fig. 2. An image of the mouse epidermal stem cell layer, made by Ingrid Heumann. Epithelial cell membranes are in cyan and collagen is in white.

(Fig. 2). We spend much of our daily lives looking at and discussing such images and one another's projects, so we had to actively resist connecting the images to known research stories in the lab. Describing our familiar images in this abstract way forced us to slow down and created opportunities to see more in the images, including phenomena that did not match our experience or expectations (an example is described below).

Importantly, when we observed and described microscopy images from our lab during these activities, we had the 'artists' in the room with us, and they could explain how they generated the images and what they saw in them. This prompted us to realize that we always make observations about our microscopy data while we are in the process of generating images, rather than simply trying to observe the 'final' images. Indeed, this process starts as early as choosing which region of skin to image and extends through choosing exposure levels and colors for each channel. We played with this theme in our lab retreat activity (Box 2). First, each lab member chose one image to manipulate in several ways (changing the colors assigned to one or multiple channels, changing the crop or orientation of the image) and put those images side-by-side in one document (Fig. 3). We refer to these compilations as 'Microscopy Pop Art' because they reminded us of Andy Warhol's famous multi-colored works. We divided into pairs and swapped our Microscopy Pop Art without explanation. Each 'observer' then described the image to the 'artist-scientist'. Often, the observer's attention was drawn to something different from what the artist-scientist had been focusing on when generating the images, and multiple lab members commented that hearing the observer's perspective allowed them to access information that they had not previously noticed. For example, one artist-scientist gained a new curiosity about the pattern of collagen fibers relative to folds in the epidermis (Fig. 3). She commented that she had initially not focused on the pattern of collagen fibers, but it caught her attention during our activity for two reasons: (1) changing the collagen signal from blue to magenta made the pattern stand out, and (2) the observer, a collagen expert, had noticed and described it. This practice of having someone else describe your own image to you is similar in some ways to discussing your data in a lab meeting context, but a crucial step that we added was having the observer describe the image *before* the artist-scientist explains anything about it – this gives the observer a better chance of avoiding the artist-scientist's own biases about their data.

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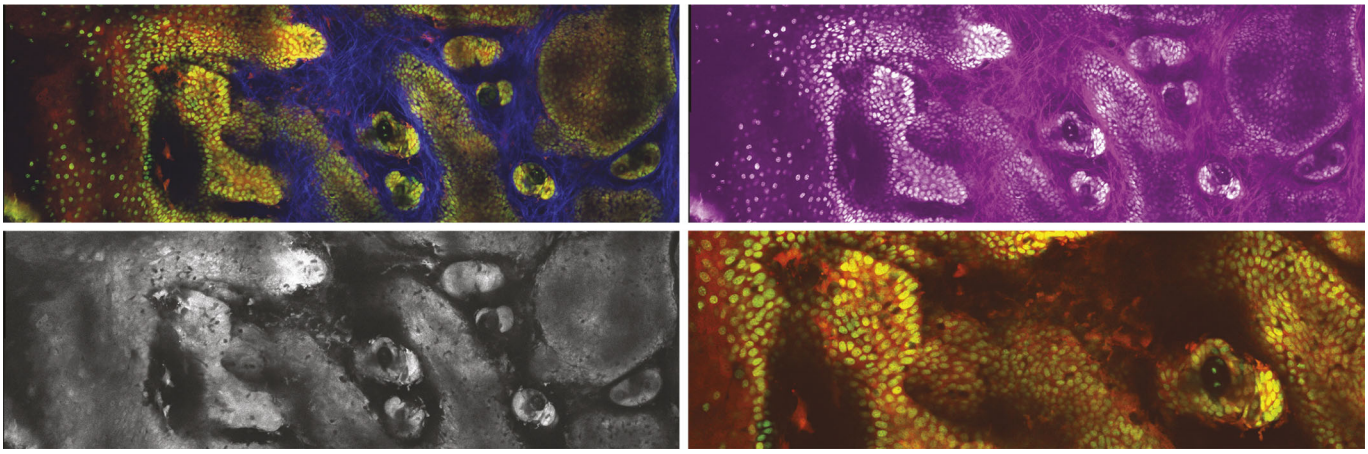

Fig. 3. A set of images of mouse skin epidermis, made by Sara Gallini. The same image is replicated four times with modifications to color, saturation and scale in each replication (we refer to this as 'Microscopy Pop Art'). In the first (upper left) image, epithelial cell nuclei are in green, fibroblast membranes are in red, and collagen is in blue.

This set of activities also allowed us to relate to one another in new ways. For example, some lab members more readily participated in the group conversation when describing microscopy images in abstract terms, in contrast to a typical lab meeting setting. We suspect that this is because describing shapes and colors de-emphasizes the viewer's subject matter expertise and how expected or unexpected patterns in the image are – two things that are valued in scientific research for good reason, but that can sometimes inhibit full participation in a group of varying experience levels. The pair-and-swap Microscopy Pop Art activity was also explicitly designed to allow each artist-scientist to choose images that emotionally resonated with them in some way: images they found beautiful or ugly, fascinating or bewildering, representing experimental struggles or successes. These emotions are almost never discussed in formal scientific venues, but we created a space to become more aware of how these emotional experiences affect our willingness to accept or reject parts of our data. The group activities also provided peer support and collective language that will support our daily research far beyond the bounds of these specific activities.

Table 1. Art-inspired methods to explore and observe our microscopy images

Articulation	Manipulation	Collaboration
• Describing the image in an 'abstract' way: describing objects as shapes and colors, and identifying objects with words describing their physical relationships rather than by pointing. • Asking questions about the image rather than stating interpretations or conclusions. • Sketching the image.	• Changing colors assigned to each channel. • Changing exposure levels of each channel. • Looking at each channel in isolation and/or merging them in different combinations. • Changing how the image is cropped and/or oriented.	• Having a colleague describe your image to you. • Explaining to a colleague why this image resonates with you (including any emotional attachment to the image or distance you feel from the image).

We came away from this practice with a set of tools to explore and make observations in our microscopy images (Table 1). Some of these tools overlap with practices many of us had already picked up in our scientific training (e.g. changing exposure levels of each channel), but others were less familiar (e.g. the art-inspired observation approach). This list of tools makes it easier to draw on them as needed during our data exploration, and to teach them to new members of the lab.

Conclusions

Through partnering with the Yale Center for British Art, our lab confronted unfamiliar objects and practiced slowing down our observational processes, allowing us to connect with our data and each other in new, profound ways. Although we applied this approach to microscopy data, researchers in any field, working with any type of data, could benefit from these activities and the fundamental lesson: look at the data in simple terms before drawing interpretations. Slowing down and separating observation from interpretation will give you a better chance of seeing more in your data, and seeing the data for what it really is rather than what you want it to be.

Repeatedly throughout this process, we kept returning to the power of the collective in gathering observations and creating deep, authentic interpretations of those observations. This concept is already embedded in so much of our scientific culture, from researching in collaborative teams, to presenting our data in front of many different groups, to the peer-review process itself. Our activities highlighted the power of a group containing many perspectives: if our lab had been more homogeneous, in terms of scientific background as well as lived experiences, we would have likely all observed the same things in the paintings and microscopy images. Moreover, if our lab did not continually work to create a culture of open communication and valuing different perspectives, the varied observations within the group would not have been voiced and could never have been integrated into the rich stories we created together.

We can never observe everything, and our interpretations will never perfectly capture biology. Nevertheless, collaborative experiences like the ones described here can provide us with new tools to explore and make sense of our data, coming closer to a fuller understanding of the biological systems that so fascinate us.

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Competing interests
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