

# Chapter 11

## It Turned into a Bioblitz: Urban Data Collection for Building Scientific Literacy and Environmental Connection



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### 11.1 The Macaulay Honors College

There is a question we like to pose at the start of our science pedagogy workshops, and it's one you can answer while you are reading this. Think for a minute about your favorite moment in learning science. Where was it? How old were you? Was it in school? Were you with others or alone? What was the root of your joy in that moment?

When we ask this question, we find – overwhelmingly – that the experiences many participants note happened early in life, sometimes in a classroom but just as often, outside of one. Even though many of the workshop participants are scientists, they seldom select a moment from high school or undergraduate courses. The annual Macaulay Honors College BioBlitz, an essential component of our honors curriculum, is an attempt to bring that spark, that frisson of excitement, to nearly 500 students a year by immersing them in a massive data collection event and research experience that connects them to the ecology of New York City in a way that few students and citizens ever experience. Part of Macaulay and CUNY's mission is to use the city as a classroom and laboratory, including both its institutions and the wide variety of habitats across the five boroughs, from bits of old-growth forests, to wetlands, to grasslands and more.

The City University of New York is the largest public urban university in the United States, serving about a quarter million matriculated undergraduates (and close to another quarter million in graduate, professional, and continuing education programs) (CUNY Office of Institutional Research, 2019; CUNY, 2021). It has 25 campuses across New York City's five boroughs. The Honors College was founded in 2001 (and became Macaulay Honors College in 2006) as a highly selective

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program to serve exceptional undergraduates at CUNY. We currently admit approximately 520 students annually, all of whom co-matriculate at Macaulay and one of our eight consortial CUNY campuses (Baruch College, Brooklyn College, The City College of New York, Hunter College, John Jay College, Lehman College, Queens College, and the College of Staten Island). Macaulay serves a diverse student body whose students are primarily drawn from the New York City metro area, including many graduates of NYC's public high schools. Many years, over half are bilingual and a large number of students are immigrants, children of immigrants, and/or the first in their family to attend college. Despite this, Macaulay is still not representative of the overall student body at CUNY, and consistently seeks ways to address this discrepancy. We recently began accepting our first transfer students, an opportunity available exclusively to associate degree students already within the CUNY system. Macaulay students who are New York State residents receive a tuition scholarship, and all students receive a laptop, dedicated advisors, access to funding for unpaid internships or study abroad, and, of course, the opportunity to participate in our seminars and learning events. In 2021, we also launched the Justice and Equity Honors Network with Barrett, The Honors College at Arizona State University. The program engages students in online discussion sessions pertaining to current events and justice, including climate and environmental justice. Because of its consortial model, Macaulay faces some distinctive structural challenges that also speak to one of the core tenets of our mission: to provide the benefits of a small, liberal arts education combined with the resources and opportunities of a large research university.

Because of our distributed model, we need to create opportunities for Macaulay students from all eight campuses to form bonds with one another and develop their identities as Macaulay students. To that end, all of our students take the same sequence of core honors seminars in their first 2 years of study, starting with the Arts in New York City, and then continuing to the People of New York City, Science Forward, and Shaping the Future of New York City. All of our seminars (capped at 20 – a rarity at CUNY) are focused on critical thinking in the context of lived experience, and the vast resources and challenges that New York City offers. Taught mostly by faculty on the home campuses, these core courses form a common experience for our students and allow them to be trained in critical thinking in a variety of disciplines.

In addition to the curriculum, Macaulay develops “common event” programs for each of the seminars, giving students across our eight campuses a chance to come together for memorable experiential learning activities that augment both their academic and social development at Macaulay. As students begin their time at Macaulay in the Arts in New York City, they participate in Night at the Museum, during which they have dedicated access to the Brooklyn Museum for one evening. Prior to attending, they also participate in workshops to help them develop skills in doing close readings of, and having conversations about, works of art. Even though the majority of our students reside in New York City, many are not routine museum-goers, and Night at the Museum gives them skills and confidence to engage with museums and art in a personally meaningful way. After Night at the Museum,

students typically craft reflections on their time there, using photographs, film snippets, and sometimes audio recordings of conversations that they had at the museum to create projects about their experience. They also continue to visit art institutions and performances throughout their seminar.<sup>1</sup> Surveys of our senior students show that many of them, from numerous majors, consider Night at the Museum a positive and beneficial experience.

After our success with launching Night at the Museum, we wanted to create an event for Science Forward that would give students a personal, authentic connection to science and make a lasting impression, as well as be useful in the seminar classroom. To do this, we mount our most ambitious event: our annual BioBlitz held at the start of the fall semester. Our BioBlitz is a 24-h biodiversity survey of a park or green space of New York City, introducing ecological fieldwork to almost 500 students, and requiring the work of dozens of scientists and naturalists to lead and supervise the data collection. To date, we have organized BioBlitzes for Macaulay students in Central Park (2013, Manhattan), New York Botanical Garden (2014, Bronx, where our event took place primarily in the Thain Family Forest, the largest old-growth forest in New York City), Freshkills Park (2015, Staten Island and built atop Fresh Kills Landfill, once the largest in the world), Brooklyn Bridge Park (2016, Brooklyn, constructed over rehabilitated industrial piers), Alley Pond Park (2017, Queens), Inwood Hill Park (2018, Manhattan, site of the only old-growth forest on the island, the Shorakapok Preserve), and Green-Wood Cemetery and the Gowanus Canal (2019, Brooklyn, where the Gowanus has been designated a Superfund site). Our 2020 and 2021 BioBlitzes were held remotely and students collected iNaturalist observations from wherever they were located to contribute to a geographically-distributed, whole-class dataset. iNaturalist is a free, openly available database and social network where people can upload geotagged and time-stamped photos of living things and have an engaged community of users help them with identification (iNaturalist, 2021a).

At the BioBlitz, students participate in authentic data collection, and in turn, use those data during the rest of the fall semester to complete research projects, culminating in a cross-campus poster session at the end of the semester. The BioBlitz is a resource-intensive, but beloved, tradition at Macaulay and is the product of our commitment to student-centered pedagogical innovation, and our hard work to bring together a logistically complex event. Macaulay understands that it occupies a position of privilege within CUNY, but we believe that our model demonstrates best practices and potential outcomes for *all* students in a public university, when properly supported and resourced, not just honors students. We maintain that a BioBlitz is the type of experience that can be brought to a variety of students and educational settings, regardless of the student population, and such an event is also adaptable to different budgetary and pedagogical concerns. In this chapter, we will describe how we developed our Science Forward skills curriculum and how the BioBlitz is an integral part of that framework. We will detail how this massive data

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<sup>1</sup>Due to the COVID-19 pandemic, Night at the Museum could not be held in 2020 and 2021.

collection event becomes an authentic research experience in the classroom and how you can conduct your own BioBlitzes. Finally, we will describe some responses to the BioBlitz from our students.

## **11.2 The Birth of Science Forward and the Macaulay BioBlitz**

Science Forward is the second iteration of Macaulay's third sequential honors seminar, which students always take in the fall of their sophomore year. The first version was "Science and Technology in New York City" and while all of our courses have approved and shared learning outcomes, the science course became unwieldy to coordinate as the Honors College program grew from just a few sections in its first years to over 20 by 2012. Because of our distributed nature, the science course suffered from curricular drift; faculty across the campuses made many different and wonderful courses, but they were often in very narrow fields of science or sometimes were not even science courses at all. We want our students to become scientifically literate, to be able to encounter science, any science, and be able to understand why the people involved are doing what they are doing. Students were not always getting this experience, so in the beginning of 2013, then-Dean Mary Pearl (herself a primatologist and conservation biologist) set out to redesign and refresh the curriculum with two main goals: (1) creating a more engaging experience for a diverse student body, and (2) focusing on scientific skills in the context of multiple fields of life and physical sciences. We want our students to think about how the process of science and our current scientific knowledge can help to address urgent local and global challenges facing our society. We also want our students to address justice by exploring the intersection of science, ethics, and equity issues in addition to harms groups have faced on the way to scientific discovery. This new curriculum framework would be called Science Forward and we would create a companion open educational resource (OER) to share it with the broader community.

We wanted to revamp the curriculum so that students on all of our campuses could have similar experiences and platforms for conversation, without putting overly prescriptive mandates on our faculty. We also needed the course to productively serve both STEM and non-STEM majors together in the same classroom. We used these goals to reflect on the type of course we wanted our students to take, and what skills and knowledge we wanted them to gain that they don't typically get elsewhere in their college careers. The course is meant to explore science in the tradition of liberal arts, with critical inquiry at its heart. To realize this ambitious goal, Macaulay needed to draw upon the expertise of faculty from across the university but also needed a realistic implementation plan. We needed someone to take this initial proposal and develop it into a full-fledged curriculum to be taught for the first time in only a few short months. Dr. O'Donnell, an evolutionary ecologist with experience in pedagogical innovation and active learning in science education, was

hired for this task in June of 2013. The university's central administration committed support to the project under its CUNY Advance<sup>2</sup> initiative, which was a program dedicated to supporting innovative pilot projects at the university. During its existence, Dr. Brundage – who holds a Ph.D. in English and gained expertise in digital pedagogy and experiential learning events as an Instructional Technology Fellow at Macaulay during her doctoral training – served as CUNY Advance's director and provided project management and pedagogical consultation for its portfolio. The partnership that began then has continued, as Dr. O'Donnell has moved into a full-time role as Director of Science Forward, and Dr. Brundage transitioned first to Director of Teaching, Learning, and Technology, and then Director of Academic Affairs, at Macaulay.

Both of us have landed at Macaulay in non-traditional academic roles that are at once administrative and directly student-serving. Both of us also received robust training in pedagogical methods throughout our doctoral and postdoctoral work, and draw on years of classroom experience that underlies and inspires how we approach our work as non-faculty academics and teachers. While we both teach courses regularly, our day-to-day jobs have responsibilities that are typically outside of the scope of faculty lines. The types of work we do are certainly possible for faculty through summer and release time, but sustaining ongoing activities related to developing and scaling a course such as Science Forward and having an annual event like the BioBlitz would be challenging for a tenure-track faculty team and impossible for contingent faculty.

As Dr. Brundage (with Gregory and Sherwood) has argued elsewhere (2018), in the rise of alternative academic or “alt-ac,”<sup>3</sup> roles, “makers” and “disruptors” are often highly valued, but universities also need to cultivate connectors: those who do the carework required to bring together disparate participants, stakeholders, departments, and other branches necessary to do and sustain complex, innovative projects such as creating the companion Science Forward OER video series and unique events like the BioBlitz. While BioBlitz itself invites reflections on environmental sustainability, our work also highlights sustainability as a labor issue. Here, we assert that the BioBlitz draws upon our background as project managers *and* pedagogues, and is enriched by our academic training and our cross-disciplinary approach to problem-solving and intellectual exploration. We are also firm in our belief that the technical execution of the BioBlitz cannot be separated from the emotional labor – the carework built into project management – that is required to provide outstanding and inclusive experiences for our students and team leaders. Because we, as a partnership, do the soup-to-nuts planning and implementation (everything from site selection to bug spray) we are able to constantly build, adapt, and iterate from year to year during planning, and minute to minute during the

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<sup>2</sup>CUNY Advance was funded from 2013 to 2016 and was not affiliated with NSF ADVANCE.

<sup>3</sup>“Alt-ac” is a term that has been in circulation since approximately 2010, and refers to careers for PhDs that are off the tenure track, and may be within or outside of academia, but draw upon expertise gained in PhD training (Manzo & Renner, 2015).



BioBlitz itself. The multiple types of services we provide are facilitated by being in alt-ac connector roles at Macaulay.

Securing both of us to work on the Science Forward curriculum project added diversity of career types to the planning committee tasked with building the Science Forward framework. Because we knew we were going to be building an interdisciplinary science curriculum, it was important for the committee to include faculty from both the life and physical sciences. There were faculty from chemistry, wild-life biology, ecology, astronomy, and climate science included. In addition to having multiple perspectives from within science, our committee also included representatives from the humanities and social sciences. All were interested in improving undergraduate science education in the context of Macaulay's liberal arts curriculum and this diversity of career-type and academic background aided our efforts.

The committee was tasked with stepping out of their discipline-specific silos and agreeing on a framework that highlights the common skills that scientists employ when they do their work. The scientists were able to enumerate the skills they use in their fields and the topics to be used in the course as the context for the skills. A key aspect to the functioning of this committee was the inclusion of perspectives from outside of the sciences. Our humanities representatives (including Dr. Brundage) had experience teaching survey courses that are similar to what we were trying to build for science and they helped to focus our efforts on making the common narrative thread (science skills) clear throughout the curriculum.

Required undergraduate science courses are often burdened by the sheer volume of content faculty must cover with students and are almost always tied to specific disciplines. Many instructors acknowledge that teaching scientific skills is important but feel that they need to prioritize covering the course content over teaching about the process of science (Coil et al., 2010). However, evidence suggests that students learn better with a more student-centered, active approach that focuses on core concepts and competencies (Petersen et al., 2020). In a typical, lecture-based science course, there is scant time to explain and reflect on how a simple 101-level experiment relates to the larger research work in climate change or drug development, for example. At the same time, the amount of scientific information that we (generally) encounter and need to evaluate daily is staggering, touching on intimate aspects of life like the food we eat, water we drink, air we breathe, medications we take, and climates we experience. In an age of fake news and science denial, creating a scientifically literate population is a critical need. Our Science Forward curriculum does just that, and the BioBlitz and experiential learning are cornerstones of how we connect the dots from science as an academic pursuit to science as a human endeavor that has meaning and context in lived experiences.

After several committee meetings and many spirited debates, we defined the backbone of our Science Forward framework, the Science Senses, which includes those scientific skills that we wanted our students to learn and practice. Having Science Sense means using these scientific skills to distinguish science from non-science and from pseudoscience; to recognize how people collect and process facts into knowledge; to question and evaluate information that is presented as scientific. Our overarching learning goal was to produce students who are informed

Science Sense	Skills include
 <p>NUMBER SENSE</p>	<ul style="list-style-type: none"> <li>Being able to apply basic mathematical reasoning</li> <li>Having a sense of scale</li> <li>Making order of magnitude estimates</li> </ul>
 <p>DATA SENSE</p>	<ul style="list-style-type: none"> <li>Making measurements</li> <li>Measuring uncertainty</li> <li>Recognizing bias</li> <li>Using proxies</li> <li>Managing data sets</li> <li>Doing statistical analysis</li> <li>Using mathematical models</li> <li>Finding relationships and trends</li> <li>Visualizing data</li> <li>Interpreting graphs</li> </ul>
 <p>KNOWLEDGE SENSE</p>	<ul style="list-style-type: none"> <li>Asking a scientific question</li> <li>Using proper experimental design</li> <li>Communicating results to scientists &amp; the public</li> <li>Understanding how science makes progress</li> <li>Thinking critically</li> <li>Being reasonably skeptical</li> <li>Making evidence-based arguments</li> <li>Applying scientific knowledge</li> <li>Understanding the intersection of science &amp; ethics</li> <li>Distinguishing science from pseudoscience</li> <li>Acknowledging equity issues in science</li> </ul>

**Fig. 11.1** A sample of the general types of skills that fall into each of the Science Sense categories (Number Sense, Data Sense, Knowledge Sense) in the Science Forward curriculum framework.

consumers, evaluators, and/or practitioners of science. The committee categorized the Science Sense skills into Number Sense, Data Sense, and Knowledge Sense (see Fig. 11.1 for a sample of some of the Science Sense skills). Number Sense skills focus on basic numeracy, unit conversion, scales, etc. Data Sense skills include what a scientist does with those numbers: collecting data, doing analyses, visualizing results, etc. Knowledge Sense skills are those that deal with the creation of knowledge from scientific evidence and also include skills related to the philosophy of science: what does it mean to ask a scientific question or to be reasonably skeptical, for example. Science Forward requires an interdisciplinary context so that students understand that these skills are common across all fields of science. A scientist needs to know why it's important to establish a hypothesis before looking at the results of an experiment whether that experiment involves invasive plants or photons. Likewise, we consider providing all students with the foundational knowledge to navigate the scientific information they will encounter in day-to-day life to be a



pressing social justice matter, whether they will become scientists or not. We support the implementation of our novel curriculum with an openly available and accessible<sup>4</sup> video library and web resource we created for it, the Science Forward OER (O'Donnell et al., 2014a).

Much research has suggested that explicitly teaching science skills helps undergraduates succeed in their future coursework, but despite faculty recognition of this, few programs exist with this purpose (Coil et al., 2010 and references therein). Training in these skills is clearly important for students who plan on becoming scientists and based on comments we have heard from our students, they do appreciate this. Dr. O'Donnell has had students tell her that they like that they can get into the reasoning behind experiments and research programs and that they do not have the opportunity to do this in their introductory science classes that are more focused on memorization. Additionally, these skills are important for all students, regardless of major, because all students are going to encounter scientific information or information presented as scientific in their daily lives. Students should be able to critically evaluate claims that they see in their social media feeds, for example.

With the interdisciplinary skills framework set, the second major innovation of Dr. Pearl's original proposal was the inclusion of a massive data collection event to start the course: a BioBlitz. Because of time and space constraints across the different campuses, there is no capacity for this course to have a formal lab component, but we felt it was very important to give our students hands-on experience with science. What better way to have students hone their scientific skills than by having them actually engage in authentic data collection and interaction with actual scientists? Having the BioBlitz included as an essential experiential learning component of Science Forward helps us achieve three goals. First, it creates a student-generated data set that can be used in class to practice the Science Sense skills. Second, it allows our students to interact with naturalists/scientists in the field who can model for them observational skills and how to think of the city as a laboratory. Finally, the BioBlitz builds inclusive connections in our student community; all students from our eight campuses are shuffled together on teams at the event.

### 11.3 How the BioBlitz Happens

The BioBlitz is a part of our authentic research experience in Science Forward, but what is a BioBlitz? In general, a BioBlitz is an intense species survey that takes place in a specific location in a defined period of time, typically 24 h. However, there is no real hard and fast definition of BioBlitz. The term "BioBlitz" was first used by the US National Parks Service in 1996 when they surveyed Kenilworth Park in Washington, DC; no one person or organization owns the term "BioBlitz" itself

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<sup>4</sup>The Science Forward videos come with closed captioning, written transcripts, and a version of the video with audio descriptions of the visual images.



(Droege, 1996). The National Parks Service continues to hold annual BioBlitzes and, for their centennial celebration in 2016, they held many BioBlitzes across the country (National Parks Service, 2019). BioBlitzes are often meant to be celebrations of nature and, usually, these are public events where “citizen scientists” can aid in cataloging the biodiversity of their local parks. We use “citizen science” here to indicate a global citizen of our whole society or a member of the public, not as a citizen of a particular nation. There are ongoing discussions about figuring out a new term for this type of amateur participation in the scientific process due to the exclusionary nature of the word “citizen” (see discussions in Eitzel et al., 2017; Cooper et al., 2021).

Our BioBlitz is slightly different from a typical, citizen science event in that participation is restricted to our own students, due to space limitations on our survey teams. The Macaulay BioBlitz is for all Macaulay sophomores (approximately 500 students annually) and is the kickoff event for their required Science Forward seminar. The Macaulay BioBlitz is typically held in early September, and students use the data they collected during BioBlitz and other relevant data sets to complete a research project and present a poster at our STEAM Festival in December. STEAM stands for Science, Technology, Engineering, Arts, and Technology. At Macaulay, the STEAM Festival is attended by first-year students in our Arts in New York City seminar and sophomores in Science Forward. Students present their final projects in poster sessions or gallery-style displays and can engage in conversations that bridge arts and sciences and link our curricula across years and students across campuses.

The BioBlitz is set within a series of courses and events that connect Macaulay students to New York City and ask them to deepen their understanding of how the city works, their role in creating a more resilient and just city. The curriculum and events invite them to make full use of the many resources, spaces, and institutions that New York has. In addition to the aforementioned Arts in New York City, which all students take in the fall semester of their first year, students take the People of New York City (a social sciences course) in the spring of their first year, followed by Science Forward and then Planning the Future of New York City (a public policy and urban planning course) in the fall and spring of their sophomore year, respectively. Most of our students have spent their entire lives in New York City, and these four core seminars are meant to introduce basic methods in humanities, social sciences, life and physical sciences, and public policy. We see this series of courses as an invitation to our students to understand that they are entitled to the spaces and resources of New York, but also carry the responsibility to be stewards of and ensure a more sustainable, equitable future for NYC. We believe this is best accomplished through a mixture of classroom work and hands-on direct work in these spaces.

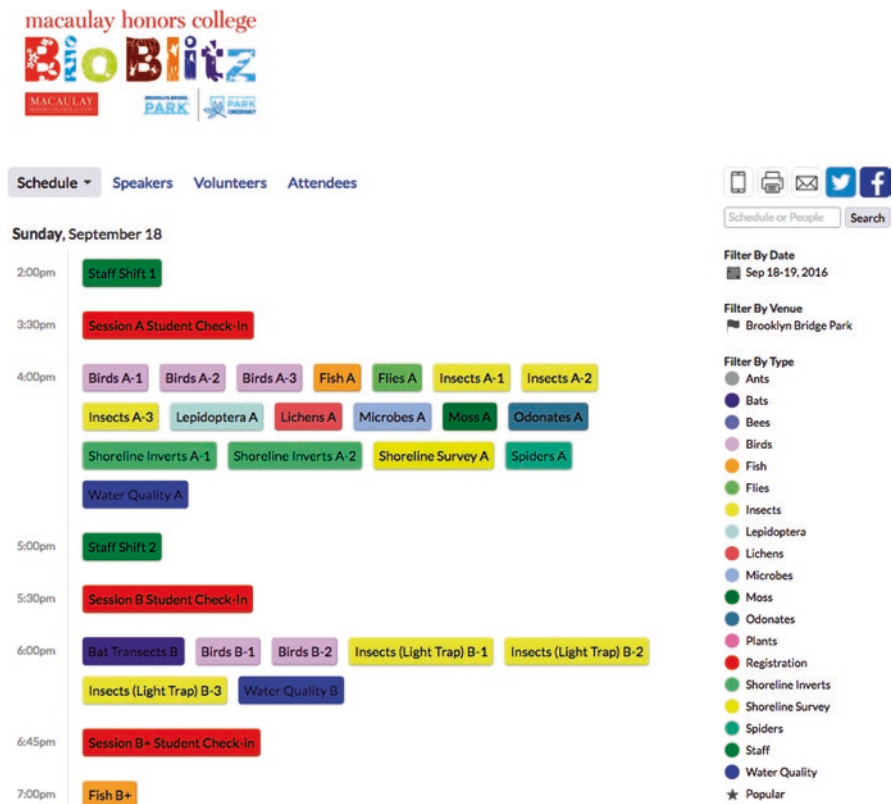
In order for the BioBlitz to achieve such broad and ambitious goals, we have a structured logistical organization that ensures student-to-student and student-to-scientist interaction. We have our students sign up for 3-h shifts to be at the BioBlitz. This does not include travel time to and from the park, but in some years, we provide charter buses to take our students from a central location to the site. During their shift, students are assigned to teams led by taxonomic experts and they are tasked with finding and documenting as many species as possible within that shift

as they can. BioBlitzes can have generalist or specialist teams. Our teams are taxon-specific; in 2017, for example, we had teams searching for ants, bats, bees, beetles, birds, fish, flies, herps, lepidopterans, lichens, microbes, odonates, plants, pond invertebrates, spiders, and even one abiotic team monitoring water quality. All data are collected on paper and/or via the iNaturalist app and are made public for all to share. Science Forward faculty are also invited to participate at the BioBlitz.

Preparing for the Macaulay BioBlitz takes months of planning and coordinating with the host location. We usually begin by identifying a willing host organization and initiating legal agreements for individual and shared responsibilities. Since our students are from all over New York City, we have made a point to include all boroughs in our BioBlitzes: Central Park in Manhattan in 2013, New York Botanical Garden in the Bronx in 2014, Freshkills Park on Staten Island in 2015, Brooklyn Bridge Park in Brooklyn in 2016, and Alley Pond Park in Queens in 2017. We then started to cycle back through boroughs with Inwood Hill Park (Manhattan) in 2018 and Green-Wood Cemetery and the Gowanus Canal (Brooklyn) in 2019. We were in the midst of planning a 2020 BioBlitz at Randall's Island (technically part of Manhattan, but situated between the shores of Manhattan, Queens, and the Bronx) when the COVID-19 pandemic hit. In 2020 and 2021, we shifted to fully remote BioBlitzes, inviting students to submit observations via iNaturalist from wherever they were located during the month of September. In the remote setting, students are required to attend one of several webinars we set up to include panels of taxon leaders who describe how to make iNaturalist observations of their particular group of interest. Students get a chance to talk with the taxon leaders in this setting.

After a location is determined, we begin to call on our network of scientists, naturalists, and local nature lovers with taxonomic expertise to lead the teams at our BioBlitz. From our experience, we have noticed that people who choose to lead teams are generally people who, in addition to being experts in a particular type of organism, love to share their knowledge with our students and demonstrate how they go about making scientific observations. We have many returning taxon leaders every year, including some that have been with us for nearly all of our BioBlitzes! We build the day's schedule based on the taxon leaders' availability, park restrictions, sunrise/sunset, and tides. We also survey students for any ADA or other accessibility needs. We are committed to creating solutions that will allow the full participation of all students. The result is multiple concurrent taxon-specific teams distributed throughout the area we are surveying (see Fig. 11.2 for an example). We open student registration for the BioBlitz before classes start and students can choose to register for any open shift. This way we can control how many students are at the BioBlitz at any given time and we get a mix from all of our campuses to build a sense of community among our distributed students.

In addition to our taxon leaders, the BioBlitz requires Macaulay staff to be onsite coordinating the day. We (Drs. O'Donnell and Brundage) are present for the entire duration of the BioBlitz, plus set up and clean up. We have a cache of equipment that our leaders and students need to facilitate their work, with everything from



**Fig. 11.2** The first few hours of the 2016 Macaulay Honors College Brooklyn Bridge Park BioBlitz as seen in the Sched app showing staff shifts, student check-in, and concurrent taxon survey teams

microscopes, to heavy-duty boots, to UV protection goggles to use at our insect light trap, to aerators for fish boxes. We also have pop-up tents; signage; tables and chairs; T-shirts for our students, leaders, and staff; first aid kits; snacks; water; sunscreen; and bug spray. Equipment is inventoried and replenished every summer, and usually moved to the survey site for storage sometime in the week before the event, with pick up the week after. During the BioBlitz, Macaulay staff work in shifts checking in students, providing assistance to taxon leaders, and providing general logistical support. We sometimes attract the attention of the local media and field questions and coordinate with them on the kinds of reporting they would like to do. We also ensure that we do a complete cleanup of the areas we use. On the Science Forward OER, faculty are provided with lesson and project ideas for incorporating personal reflections and scientific analysis of the BioBlitz experience and data into their classes (O'Donnell et al., 2014b).

## 11.4 The Macaulay BioBlitz as an Authentic Research Experience

Experiential learning is one of Macaulay's key curricular themes. The BioBlitz represents the key experience in Science Forward and it was proposed to integrate an authentic research experience into the core requirements of our students. We want our students to learn how science works by engaging in an investigation based on the BioBlitz data, but led by their own lines of inquiry. Although Science Forward is an interdisciplinary course, we followed recommendations of reports such as *Vision and Change* (AAAS, 2011), which states that whether or not students who participate in a research experience go on to careers in scientific research, the experience itself improves their ability to understand how scientists work. The experience also prepares them to better evaluate scientific claims that they may encounter in their daily lives.

The positive outcomes of integrating a research experience into a science course are supported by a growing body of research. For example, Gasper and Gardner (2013) showed increased critical thinking ability and understanding of the nature of science after an authentic research experience was integrated into their introductory biology course. But what does it mean to be "an authentic research experience?" In a large national survey of biology faculty conducted by Spell et al. (2014), it was shown that faculty define authentic research experience in many different ways, however, common themes do emerge, such as incorporating experimental design, data collection, data analysis, and presentation. When developing Science Forward, we wanted to touch on all of these themes as they directly relate to the skills training we were hoping to instill in our students.

The Macaulay BioBlitz serves as the data collection opportunity for the authentic research experience in Science Forward. We want our students to be thinking about making meaningful observations and to interact with enthusiastic experts. We also recommend that students think about what kinds of empirical questions they could ask about the creatures and environment they are observing. Both students and faculty can access some BioBlitz data immediately as observations are uploaded to iNaturalist. About 2–3 weeks after the event, the full data set, including all of the data collected on paper data sheets, are made available to the faculty first to allow students time to come up with their questions before seeing the full data set.

The rest of the research experience takes place in the classroom during the semester. The Science Forward framework requires that the BioBlitz experience be used during the course. We strongly encourage the ~30 faculty who teach the course to use the BioBlitz experience as the basis for an original student research project, which in most cases, will make up the largest portion of a student's grade. Given the length of the semester and the placement of the BioBlitz in the schedule, these projects usually are not highly complex studies, but they do give our students the opportunity to take ownership of a part of the BioBlitz data and think deeply about what those data mean.

Science Forward faculty are provided with a recommended project scaffold to use so that students can take time to explore different aspects of the scientific process (available at the Science Forward OER (O'Donnell et al. 2014a)). Students were out in the urban habitat and should then think of testable questions they could answer using the data gathered at the BioBlitz. They may also incorporate other open data sources or even revisit the BioBlitz location to collect more data. The students then decide on how they want to analyze the data: what comparisons will they make and what statistical analyses will they perform. In the project scaffolding, we recommend that students write this part up as a brief project proposal. We have had students compare bat activity in different areas of a forest using chi-square analysis, calculate diversity indices for bird communities, and compare diversity across different years of the BioBlitz, for example. We have also had students collect more data to investigate lichen diversity across an assumed pollution gradient, human impact on bird abundance, and even survey data on their classmates to gauge response to the event itself.

The final step in this research experience is communicating results at our semester-closing common event for Science Forward: the Macaulay STEAM Festival. At this event, all (approx. 500) of our Science Forward students share the results of their semester-long projects as research posters. In class, our students determine how to clearly communicate what they have found out in the visual format of a poster. The activity models preparation for a professional meeting and calls on specific skills related to communicating scientific information to a scientific audience at the STEAM Festival. Our students get the opportunity to tell their classmates about what they have done and to interact with our science faculty and graduate students who are interested in their findings.

By having our students collect data, ask their own questions, design their analyses, and communicate their results, we are hitting major themes of an authentic research experience (Spell et al., 2014). Our students are participating in the actual process of science and employing many of the Science Sense skills that we want them to be honing in the Science Forward course.

## 11.5 “So, You Want to Do a Bioblitz...”

Our annual BioBlitz will continue into the future and there are many other BioBlitzes occurring around the world at any given time. At Macaulay, Dr. O'Donnell also organizes the New York City arm of the City Nature Challenge, which is an annual global BioBlitz for urban biodiversity run by the California Academy of Sciences and the Natural History Museum of Los Angeles County (Young & Higgins, 2021). If the reader is interested in starting their own BioBlitz, we can offer a few tips. The first thing to do is determine what the outcome of the BioBlitz is going to be: will it be a research experience integrated into class? Will it be for public engagement with nature? Determining your outcomes beforehand allows you to structure the event in a way that best achieves these goals.

The scope of your BioBlitz depends on your purpose and participants. Our BioBlitz is tightly scheduled because we are guaranteed about 450–500 student participants and simply do not have the capacity to plan for and distribute teams if the students showed up whenever they wanted. Students sign up for a specific session and know their time commitment upfront. We also choose to have taxon-specific teams to facilitate a more diverse species list. Students are assigned to teams once they arrive, which minimizes uneven placement and eliminates requests to swap teams. Depending on our site's proximity to public transportation, we sometimes provide shuttle bus service to the event, so we need to figure out how large each wave of students will be, and how many buses we need to accommodate them. This may be less of a challenge if you are in an area where most students use personal vehicles as their primary mode of transportation, and your sites have ample parking.

Many BioBlitzes are less structured than ours; they may have a smaller number of participants so it might make sense for them to have more generalist teams so that there are fewer gaps in taxonomic coverage. With the broader use of iNaturalist, we are also seeing more and more open and unstructured BioBlitzes like the City Nature Challenge. BioBlitzes like these require a robust local community of iNaturalist users to help with identifications synchronously or asynchronously. You can even participate in a "Personal BioBlitz" (Pollock et al., 2015) which takes place over many weeks and seeks to increase biodiversity awareness through the documentation of a personal life list of species in a friendly competition with other users.

Whatever your scope, start planning early. Yes, it is true that we planned the 2013 Central Park BioBlitz in about 3 months, but this is not ideal for finding experts to lead teams or for the organizers' mental health. Ironing out the legal agreements alone can take 6 or more months for some locations, even if the hosts are all on board already. It is vital to have formal agreements about the event, delineating specific logistical and monetary responsibilities of each party, including access to buildings and spaces at off-hours, safety information and waivers, and who has key decision-making powers, such as event cancellation due to inclement weather. Additionally, you must also consider governmental and institutional permits and timelines for the survey activities you are conducting, such as state/city research permits and Institutional Animal Care and Use Committee (IACUC) authorization. With the 2015 Freshkills Park BioBlitz, for example, we were holding a CUNY event in a city park with its own conservancy on land jointly held by the NYC Parks Department and the NYC Department of Sanitation and students were checking in at a ferry terminal operated by the Department of Transportation. We had to have agreements and/or waivers in place for all of those involved institutions. Then for the surveying activities, we had a NYS DEC License to Collect and Possess – Scientific, an NYC Parks Research Permit, and IACUC approval from City College.

At our BioBlitzes, we strive to provide easy and positive experiences for our students and our taxon group leaders, which means a meticulous organization of both logistics and objects. We get T-shirts printed for all of our participants, with students in one color and scientists, staff, and volunteers in another color. It is incredibly helpful to have all participants visually identifiable and to be able to tell



at a glance who is a student and who is working. If you cannot afford to do this, we recommend that you try to have T-shirts for your leaders and staff so that students (and you!) can easily locate them. We also assign students a team number, rather than a team name. Faced with a choice like “flies or fish” students generally show some vertebrate bias and choose fish. We learned the hard way that students can “forget” which teams they have been assigned if they believe their assigned taxa are unfamiliar, uninteresting, or frightening. But what we have also witnessed is that an enthusiastic leader can absolutely sway attitudes about the organisms in team survey work! We do, however, ask for allergy information and won’t place a student allergic to bees on the bee team, for example. We also pre-assign any students with disabilities to the team we have mutually agreed will be best for them. We work with our taxon leaders to determine the ideal group size, assign students in accordance with their wishes, and pre-determine where in the park their work will take place. Taking this step is especially important for certain groups like the birding teams, which need to be small to remain quiet.

If you are going to incorporate a BioBlitz as a recurring event, consider your budget and space for equipment. We have acquired over 35 large plastic boxes (upwards of 90 cubic feet) of equipment over the past BioBlitzes. We are at capacity for storage in our building. Borrow equipment when you can. We also carefully inventory the equipment with a checklist and keep the bins organized and clearly labeled by taxon. Having the equipment (and other materials for registration etc.) carefully organized relieves a lot of stress onsite, when time is short and the registration area is crowded. Do what you can to help teams self-start! Also plan to thoroughly familiarize yourself with the area you will survey: time how long it takes to walk from the check-in area to the survey areas, note any obstacles, and anticipate challenges such as moving, guarding, and setting up equipment. If leaders will be working with two consecutive groups of students, will they be able to come back to registration to meet the new group, or will they need to stay with equipment in the field? We find it useful to print a poster-sized map and physically move objects around it representing teams and times to get a feel for how the day will stitch together. While we keep a detailed, private spreadsheet of all the logistical information, we have also used [sched.com](https://www.sched.com) (an event organization tool, see Fig. 11.2) and other graphics to make an easily readable and shareable timeline of the day. Whatever form your BioBlitz takes, make sure to build some enjoyment in for yourself, too! Enjoy your surroundings, log some observations, and appreciate the experience you are bringing to your students.

## 11.6 The Value of the Macaulay BioBlitz

Developing curricula that instill scientific literacy, including procedural knowledge, evidence evaluation, and that take into account science’s role in everyday life is critical across industry, social action, and the personal realm (Duggan & Gott, 2002). With our new Science Forward framework, we have created a course for our



students, both STEM and non-STEM majors alike, that focuses on these skills and the role of science in the world. Our annual BioBlitz is integrated into this framework as a highly engaging research experience for our students who get a chance to participate in the actual process of science. In class, students explore how to ask an empirical question of these data, how to manage ecological data, what statistical analyses are appropriate, and how to communicate clearly to both a public and a scientific audience. Our BioBlitz is a worthwhile logistical challenge that fosters these opportunities.

Besides skills training and engagement with the scientific process, there are other important outcomes from the BioBlitz experience. Unlike many research experiences, such as those that take the form of apprenticeships in labs, Science Forward projects are usually a singular exploration rather than an iterative one. However, our data do live on in their open format. Anyone can visit our BioBlitz website<sup>5</sup> to access the data or download BioBlitz observations from iNaturalist. Using the iNaturalist platform also means that those BioBlitz observations that become what iNaturalist calls “Research Grade”<sup>6</sup> can be seen and used by a wider audience through the Global Biodiversity Information Facility (GBIF), an open repository of ecological datasets (GBIF.org, 2021). Research Grade iNaturalist observations get uploaded weekly to GBIF where they can be accessed by researchers looking for species occurrence data (Ueda, 2021). Our students are contributing to a worldwide dataset that any scientist can use to ask ecological questions about our changing planet. For example, iNaturalist data were used to document butterfly decline in the western US (Forister et al., 2021). iNaturalist data can even be used to address issues regarding sustainable urban planning (see Cambria et al., 2021 for a European example).

In the process of collecting these data for our BioBlitz, students are potentially also engaging in biodiscovery, documenting new species or interactions in a particular area (Hitchcock et al., 2021). For example, at our first BioBlitz in 2013, several students on the plant team led by Daniel Atha of the New York Botanical Garden, documented species that had never been reported at Central Park before, including *Plantago rugelli* observed on iNaturalist by Erisa Gjinaj (2013), *Persicaria extremiorientalis* observed by David Kleyman (2013), and *Cyperus iria* observed by Jonathan Chevinsky (2013) (Atha, personal communication). If one considers the impact on the iNaturalist database itself, our BioBlitzes often have students making the only records of some species in the area and our BioBlitz observations can make up a large percentage of a host park's total observations (see Hitchcock et al., 2021). Our BioBlitzes have also brought new, knowledgeable users to iNaturalist when our taxon leaders sign up as they prepare to lead teams for us. For example, Daniel Atha started the New York City EcoFlora project, an effort of NYBG to engage New Yorkers with the plant species around the city as they follow monthly themed quests to make iNaturalist observations (Boom et al., n.d.). Susan Hewitt, mollusk

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<sup>5</sup><http://macaulay.cuny.edu/eportfolios/bioblitz/>

<sup>6</sup>Research Grade observations are those where 2/3 or more of the iNaturalist users who contribute identifications agree on the species (iNaturalist, 2021b).

taxon leader at the 2014 BioBlitz, is the ninth most prolific observer on all of iNaturalist (as of this writing) with over 93,000 verifiable observations (she's twelfth for all observations) (iNaturalist, 2021c). Our BioBlitz has also been the inspiration for further surveys of the Central Park flora (Atha et al., 2020) and lichens at Freshkills Park (Allen & Howe, 2016). At a large scale, our students can feel more connected to a global community of naturalists through the contributions they make via iNaturalist and the interactions they have with the users of that database.

Another important outcome is students seeing and interacting with scientists in one of their natural habitats. Granted, our sample is not representative of all scientists, but students are getting the opportunity to have meaningful conversations about the work that these scientists do in an intimate group outside of the lecture hall. We hope that this shatters the misconception of all scientists being isolated people in sterile labs wearing white coats and safety goggles.

The BioBlitz experience also serves to instill a sense of place in our students at local and global levels. As a common event, the BioBlitz brings together our eight campuses and fosters a sense of community within the entire class. As an event that is focused on the green spaces of New York City, the BioBlitz connects our students to the urban habitat. They have even had the opportunity to explore areas not yet open to the public: the Hallett Nature Sanctuary in Central Park was not open yet when we had the 2013 BioBlitz, and Freshkills Park is still not entirely open to the public. Opportunities like these make the event special for our students and introduce them to ongoing stewardship efforts that the city supports. Students can feel proud that they are able to contribute to the protection of these natural areas that are a part of their urban homes. In a few cases, our students and naturalists are establishing the baseline species list in areas that had never been surveyed at this level before. Data like these may be particularly useful as more research effort is directed at questions about the importance of urban biodiversity in global conservation efforts. There remain many questions to be answered about not only the ecological processes happening across networks of urban green spaces (Lepczyk et al., 2017), but also how to effectively use that information in the context of the social, economic, and other human considerations that factor into effective urban green space management (Aronson et al., 2017).

Students can also make connections between their BioBlitz experience and other aspects of our Science Forward and honors curricula. All in-person Macaulay BioBlitzes have been held on the unceded territory of the Lenape people and we want students to acknowledge that fact and pay proper respect to the original inhabitants of the land our campuses sit upon. We incorporated our first formal land acknowledgment (drafted by members of Macaulay's Teaching and Learning Collaboratory) into our 2019 BioBlitz, and Dr. O'Donnell has created our current version (O'Donnell, 2021). We want students to think about how the landscape has changed with the impacts of colonization and we make sure to point them to resources like The Lenape Center (2021), *Mannahatta* (Sanderson, 2009), and The Welikia Project (WCS, 2008) so they can find out more. We also want students to think about how land use has continued to change even beyond colonization and which groups have been harmed by that process. BioBlitz host sites that are in the

process of transformation from heavily human-damaged spaces to parkland are good examples of our attempts to recover from this destruction (Freshkills Park and the Gowanus Canal, for example). We also encourage faculty to use the BioBlitz experience as a way to broach themes of environmental justice in their classes.

Participating in BioBlitz is usually unlike any other science course experience students have had and gets many positive responses from our students. Because the course serves sophomores, even our STEM majors have generally not yet participated in any research activities. In September 2016, we informally surveyed 286 students when they registered to attend the BioBlitz and 82.5% were not currently involved in any research in a science lab, computer lab, or in the field, and 32.8% considered themselves unlikely or highly unlikely to engage in scientific research outside of their coursework. In addition to knowing that the event boosts students' research experiences, the qualitative feedback we get from students is also valuable to us. We have seen students take tentative, wader-encased steps into the East River, and then be amazed at what a seine net hauls in. We have witnessed students literally yelling with excitement after catching an insect in a net, and watching with amazement as a scientist delicately handles a bat and shows them how to assess its health. We hear from our team leader scientists that the BioBlitz gives them a unique way to interact with and relate to students, sharing the work that they love with students. The BioBlitz has lasting effects on students, too. In senior surveys (administered over 2 years after the graduating students' BioBlitz experience), we get comments such as, "BioBlitz was very interesting because I got to learn about the natural environment within the city, instead of thinking of wildlife as only something you can find out in the wilderness." Another graduating student articulated the benefit of interpersonal skills that experiential learning imparts: "Going to unique Macaulay opportunities such as . . . bioblitz, museums, etc., has opened my mind to a different way of thinking. If I didn't go to these events, I would be forced to only do coursework and activities relevant to my major. Because I've explored so many different fields like art, science, history, and more, I have more skills and knowledge which makes conversing with different people so much better." Events like the BioBlitz help our students gain academic skills, but also make them informed citizens with deeper connections to the places in which they live.

We also know the BioBlitz has the potential to alter career tracks for our students, like Allegra DePasquale. She told us, "BioBlitz was one of my favorite events, and changed the course of my academic career. Surveying mammals with Dr. Pearl showed me how fulfilling fieldwork can be, and inspired me to create my own major in zoology and conservation through CUNY BA [a degree program for individualized study]. I'm now applying to Ph.D. programs in primatology. I really wouldn't be where I am if I hadn't discovered my love [of] animal biology and ecology at the BioBlitz" (private correspondence, quoted with permission). Allegra's story shows how taking students out of the classroom and providing opportunities for them to interact with scientists in a casual, personal way like they do at BioBlitz can make scientists and the professions of science personally relatable. STEM and non-STEM majors alike deserve the chance to have authentic experiences with the scientific process and to experience moments of discovery and genuine joy.

At BioBlitz, students get to know faculty and scientists in ways that are not attainable in a typical course setting, which can open personal and professional pathways. But highlighting the human face of science is a useful goal in itself, especially in our age of science skepticism. In a study of public perceptions of scientists and trust in scientific information, Fiske and Dupree (2014) explained that trustworthiness is based on competence *and* warmth. Fiske and Dupree found that while most Americans view scientists as competent, fewer view them as warm, which affects public perceptions: “Overall, communicator credibility needs to address both expertise and trustworthiness. Scientists have earned audiences’ respect, but not necessarily their trust.” Fiske and Dupree conclude, “Rather than persuading, we and our audiences are better served by discussing, teaching, and sharing information, to convey trustworthy intentions.” Our experience with BioBlitz is that it serves these same goals, connecting scientific inquiry to the fabric of the city and students’ lives. Increased trust in science as a process and scientists as people is an important aspect of developing scientific literacy – a way of knowing that we insist they have a right to develop, no matter what their backgrounds, majors, career goals, or future may be.

**Acknowledgments** We would like to acknowledge all who have had a hand in supporting both Science Forward and the Macaulay BioBlitz including Mary Pearl, Joseph Ugoretz, Janet Fu, the Science Forward Planning Committee of 2013, and the Macaulay staff who work at the BioBlitz every year. Of course, we could not have a BioBlitz without the help of the many knowledgeable taxon leaders that take our student teams out to explore. And thanks to the Macaulay students who collect the data and make iNaturalist observations. Science Forward has been funded by CUNY Advance, with thanks to the Central CUNY Administration, Ann Kirschner, and George Otte; and by the CUNY OER Initiative.

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