



Imaging Core Annual Report FY21

Amy Beaven

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Executive Summary

The Imaging Core (IC) plays a key role in research, training, and education in the Life Sciences at UMD. In FY21 alone, 51 laboratories from 16 departments in 5 colleges (CMNS, AGNR, ENGR, BSOS, SPH), plus 2 off-campus institutions (GWU, USGS) used the facility's high-end light microscopes. During the past year, the director trained 37 new researchers to independently operate the IC's microscopes, bringing the total number of trained users since FY05 to 975. Access to the facility's instruments and high-quality training has directly resulted in at least 184 publications (see Appendix 4).

In FY21, facility income exceeded expenses by \$5,019, despite the fact that mandatory COVID-19 occupancy restrictions remained in place for most of the fiscal year:

- UMD remained closed for research from 3/13/20 to 6/8/20
- Phase 1: 25% occupancy restrictions from 6/8/20 to 8/24/20
- Phase 2: 50% occupancy restrictions from 8/25/20 to 4/4/21
- Phase 3: 75% occupancy restrictions from 4/5/21 to 6/3/21
- 100%: Full occupancy resumed on 6/3/21

Most of the IC's income came from LSM980 chargeback fees. Due to the technical limitations of the Zeiss LSM710, Leica SP5x, and DeltaVision (older software and operating systems) the PI did not train new users these systems until all restrictions were lifted and in-person training resumed.

During Phases 1-3, the PI trained 37 new users on the Zeiss LSM980 using a combination of remote Zoom software training sessions and a video (made using an iPhone and iMovie) that showed the startup procedure for the instrument and basic slide-loading techniques. The training sessions were recorded and shared with the user for future reference. A 2nd training session provided hands-on, in-person experience with the microscope. The video and Zoom sessions were also used to provide several "refresher" training sessions, and to help trained users set up new configurations and/or learn about advanced techniques.

If instrument usage continues to remain stable, the Imaging Core will be able to maintain service contracts on all the instruments. However, both the Zeiss LSM710 and Leica SP5x will be ineligible for service contracts starting in 2022. At this time, the companies will stop making replacement parts for the instruments.

If the IC is to remain competitive, solvent, and self-sustaining, the director suggests we take the following actions:

1. Demo the Leica STELLARIS confocal microscope to determine if the system's technologies (FLIM, DLS) would benefit the Imaging Core users. If so, apply for funding via one of the following avenues: 1) NIH S10 2) NSF MRI (FY22), or 3) the Maryland Instrumentation Fund (if there is a new call for proposals in 2022).
2. Keep the LSM980 introductory rates unchanged, but reinstate the \$150 per person training fee (Table 12).

Implementing some or all of these recommendations will ensure the IC remains a valuable imaging resource for years to come.

Facility Mission

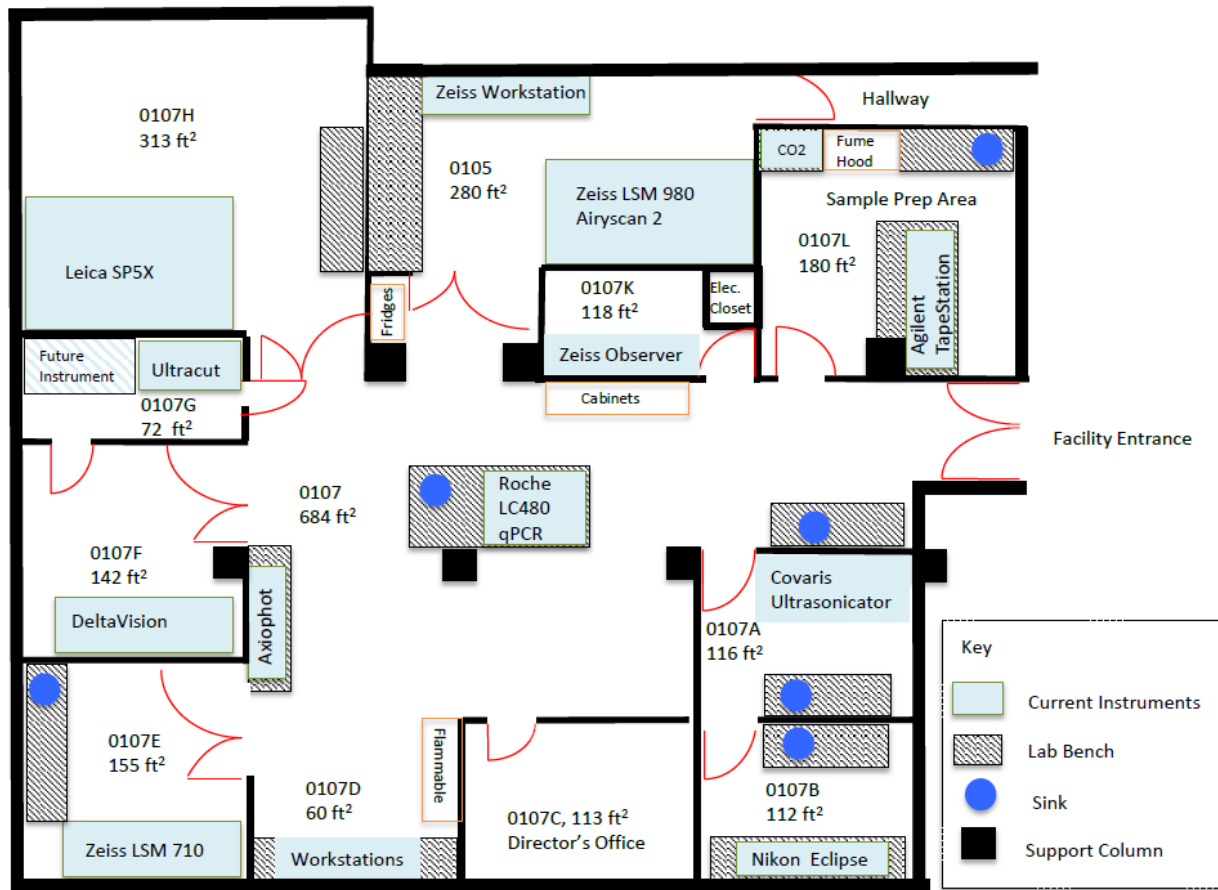
The mission of the Imaging Core (IC) is to enhance research and education by:

1. Providing reliable and affordable access to state-of-the-art light microscopy and imaging instrumentation.
2. Offering detailed training opportunities and support in basic and advanced light microscopy techniques.
3. Providing professional guidance in experimental design and image acquisition techniques.
4. Keeping researchers up to date with the latest technology and innovations in light microscopy.

Introduction/History

The Imaging Core (IC) was established in the year 2000 by the Department of Cell Biology and Molecular Genetics in order to enhance research and education at the University of Maryland. It provides students and faculty members with access to sophisticated light microscopes and imaging instrumentation whose purchase and maintenance costs far exceed the budgets of individual investigators.

Configuration of UMD Imaging Core, 0107 Microbiology Building



Total Square Feet: 2,349

The IC facility is located in 0107 Microbiology building, and includes 10 rooms, five of which are dedicated microscope space, office space for the Director, and a wet-bench lab space with fume hood. When first established, the IC contained a single confocal microscope and a deconvolution microscope. Over the years, demand for time on the instruments increased dramatically, necessitating the purchase of a second confocal in 2008. At present, the IC contains 3 laser scanning confocal microscopes (Zeiss LSM 980 Airyscan 2, Zeiss LSM710 and Leica SP5X), a DeltaVision deconvolution/TIRF microscope (installed in March 2014), a Zeiss AxioObserver fluorescence microscope (acquired in February FY14), a Zeiss AxioPhot brightfield microscope, and a Nikon Eclipse upright microscope with color camera (transferred to the facility in October 2016).

In December 2014, a PerkinElmer spinning disk confocal microscope was purchased and installed in the Physical Sciences Complex, and became the first instrument in the new Imaging Incubator facility. Following that, an ASI diSPIM was installed in April 2017, and a JPK NanoWizard 4a BioAFM in October 2017. The Director of the IC managed these instruments until transferring all responsibilities to the new Director of the IC, Stephan Brenowitz (hired in July 2017). Dr. Brenowitz left the position in April 2019. A search is open for a Lab Manager position to replace him.

The Director of the IC, Amy Beaven, oversees the routine operation of the IC and is available during normal business hours to provide training on all equipment, guidance on experimental design, assistance with image analysis, and technician-assisted microscope operation. Since taking over operation of the IC in November 2005, Ms. Beaven has trained over 932 researchers from at least 15 different departments in six colleges and three different campuses (UMCP, UMB, Shady Grove, Salisbury) of the University of Maryland.

The IC is used by a diverse group of investigators, including undergraduates, graduate students, post-docs, technicians and faculty. In addition, students enrolled in the annual 2-credit class CBMG688W/BSCI427, Principles of Microscopy, gained hands-on experience in the operation of the IC's brightfield, DeltaVision and Leica SP5X confocal microscopes until the fall of 2017, when Professor Stephen Wolniak retired. The course trained an average of fifteen students each year for over eleven years.

In the past, funding for the IC came from a combination of user fees and support from the University of Maryland. In an effort to become self-sustaining, trends in facility income, expenses and instrument usage were analyzed over time (the details of which are published in IC's FY10-19 Annual Reports). The analysis showed that a gradual increase in hourly instrument rates were necessary in order for the facility to become financially independent. As such, user fees were incrementally increased over several years in the hopes that the IC would be able to cover all maintenance and service contract costs through user fees alone. It should be noted that current instrument fees are priced competitively and still below the average rates charged at similar institutions with equivalent instrumentation (see Appendix 5).

Please see Appendix 3 for a complete list of current instrumentation, and Appendix 2 for changes in IC instrumentation since FY05.

Organizational Structure and Governance

- Director of the Facility: Amy Beaven
- Faculty supervisor: Dr. Charles Delwiche, Professor
- S10 Advisory Committee: Kevin McIver, Professor and Chair (CBMG), Charles Delwiche, Professor (CBMG), Jose Feijo, Professor (CBMG), Antony Jose, Professor (CBMG), Iqbal Hamza, Professor (ANSC), Wolfgang Losert, Professor (PHYS/IPST), Stephanie Peters (CMNS Dean's Office).

Personnel

The Director of the Facility, Amy Beaven, is the only full-time staff member within the facility. She was hired in 2005 to manage the Imaging and Genomics Core facilities and was promoted to Director in 2010. Ms. Beaven received her Master's degree in Biology in 1999 and has over 15 years of intensive experience in imaging techniques, including laser scanning confocal, spinning disk confocal, deconvolution, and TIRF. She is available during the hours of 8am-4:30pm to provide guidance in experimental design, training on all equipment, technician-assisted confocal operation and assistance with image analysis.

Outreach Activities During FY21

1. July, 2020: The director recorded (iPhone) and edited (iMovie) a video showing operation of the TapeStation to assist with new user training.
2. July, 2020: UMD's confocal representative provided access to comprehensive Zen software training videos produced by local Zeiss representatives (<https://www.zeiss.com/microscopy/us/local/zen-knowledge-base/lsm-800-900-980.html>)
3. July- August, 2020: the director assisted PI Wolfgang Losert with a lattice lightsheet instrumentation grant proposal (Beckman Foundation; not funded).
4. March 8, 2021: The LSM 980 was upgraded with a color camera, a 2.5x objective lens, and en Navigator software.
5. March - April, 2021: The director assisted PI Wolfgang Losert with a lattice lightsheet instrumentation grant proposal (Maryland Instrumentation Fund; awarded in June 2021)
6. April, 2021, 100% in-person training resumed.
7. April, 2021: The director assisted a professor from GWU on the LSM 980 Airyscan.

Summary of Facility Usage

In FY21, the Zeiss LSM 980 was scheduled an average of 21 hours/week; the Zeiss LSM710 an average of 8 hours/week and Leica SP5X an average of 10 hours/week. The combined average usage of 48 hours/week is a 26% increase from FY20. Off-peak hours accounted for 22% of the use.

51 laboratories from 16 departments in 5 colleges (CMNS, AGNR, ENGR, BSOS, SPH), plus 2 off-campus institutions (GWU, USGS) used the facility's high-end light microscopes. During the past year, the director trained 37 new researchers to independently operate the IC's microscopes, bringing the total number of trained users since FY05 to 975.

Table 1: Zeiss LSM 980 Summary Data:

Fiscal Year	Income	Total # Hours Charged	Hours used for UMCP Courses	Total # Training Sessions
2020	\$9,045	348.8	0	36
2021	\$39,039	1429.8	0	31
Total	\$48,084	1778.5	0	67

Table 2: Leica SP5X Summary Data:

Fiscal Year	Income	Total # Hours Charged	Hours used for UMCP Courses	Total # Training Sessions
2009	\$5,091	346	0	39
2010	\$18,363	1283	71	43
2011	\$24,290	1325	56	35
2012	\$21,882	1021	63	29
2013	\$21,922	932	91	35
2014	\$25,161	886	71	34
2015	\$25,576	1206	39	27
2016	\$35,865	1602	36	17
2017	\$31,802	1153	6	20
2018	\$49,599	1569	0	28
2019	\$39,378	1212	0	9
2020	\$20,995	604	0	17
2021	\$15,458	507	0	0
Total	\$335,382	13,645	432	333

Table 3: Zeiss LSM710 Summary Data:

Fiscal Year	Income	Total # Hours Charged	Hours used for UMCP Courses	Total # Training Sessions
2010	\$12,370	804	0	44
2011	\$33,448	1762	0	33
2012	\$27,895	1244	0	20
2013	\$33,889	1248	0	26
2014	\$31,471	1174	1.5	17
2015	\$27,655	964	6.5	22
2016	\$32,847	1021	7	20
2017	\$26,055	688	29	30
2018	\$35,400	1091	0	13
2019	\$42,551	1280	0	18
2020	\$28,689	865	0	6
2021	\$12,403	391	0	0
Total	\$344,673	12708	44	249

Table 4: DeltaVision Summary Data:

Fiscal Year	Income	Total # Hours Charged	Hours used for UMCP Courses	Total # Training Sessions
2014	\$317	32	0	12
2015	\$6472	376	24	13
2016	\$6,824	270	33	20
2017	\$7267	270	20	21
2018	\$12,674	423	0	6
2019	\$8,611	281	0	3
2020	\$4,516	152	0	0
2021	\$720	24.0	0	0
Total	\$47,084	1,826	77	75

Table 5: AxioObserver Fluorescence Microscope Data:

Fiscal Year	Income	Total # Hours Charged	Hours used for UMCP Courses	Total # Training Sessions
2014	\$113	23	0	0
2015	\$790	155	0	1
2016	\$1,086	198	0	5
2017	\$2066	319	0	22
2018	\$975	117	36	8
2019	\$1,338	113	57	9
2020	\$725	71	0	2
2021	\$353	35	0	0
Total	\$7,445	1040	85	47

Table 6: Nikon Eclipse Microscope Data:

Fiscal Year	Income	Total # Hours Charged	Hours used for UMCP Courses	Total # Training Sessions
2017	\$103	16	0	1
2018	\$1025	90	7	7
2019	\$2045	168	9	8
2020	\$670	75	0	6
2021	\$1,059	92	0	6
Total	\$4,901	441	16	28

Table 7: Combined Microscope Data by Fiscal Year:

Fiscal Year	Income	Total # Hours Charged	Hours used for UMCP Courses	Total # Training Sessions
2009	\$5,091	346	0	39
2010	\$30,733	2,086	71	87
2011	\$57,739	3,088	56	68
2012	\$49,778	2,265	63	49
2013	\$55,811	2,180	91	61
2014	\$57,061	2,114	73	63
2015	\$60,175	2,700	70	63
2016	\$76,622	3,090	76	62
2017	\$67,194	2,636	83	93
2018	\$100,126	3290	36	62
2019	\$93,923	3062	0	30
2020	\$64,641	2,117	0	67
2021	\$69,030	2479	0	37
Total	\$776,746	30,085.56	551	*730

*Including the old Zeiss LSM510, the total # training sessions increases to 975

Figure 1: Total number of hours used on Imaging Core instruments by fiscal year

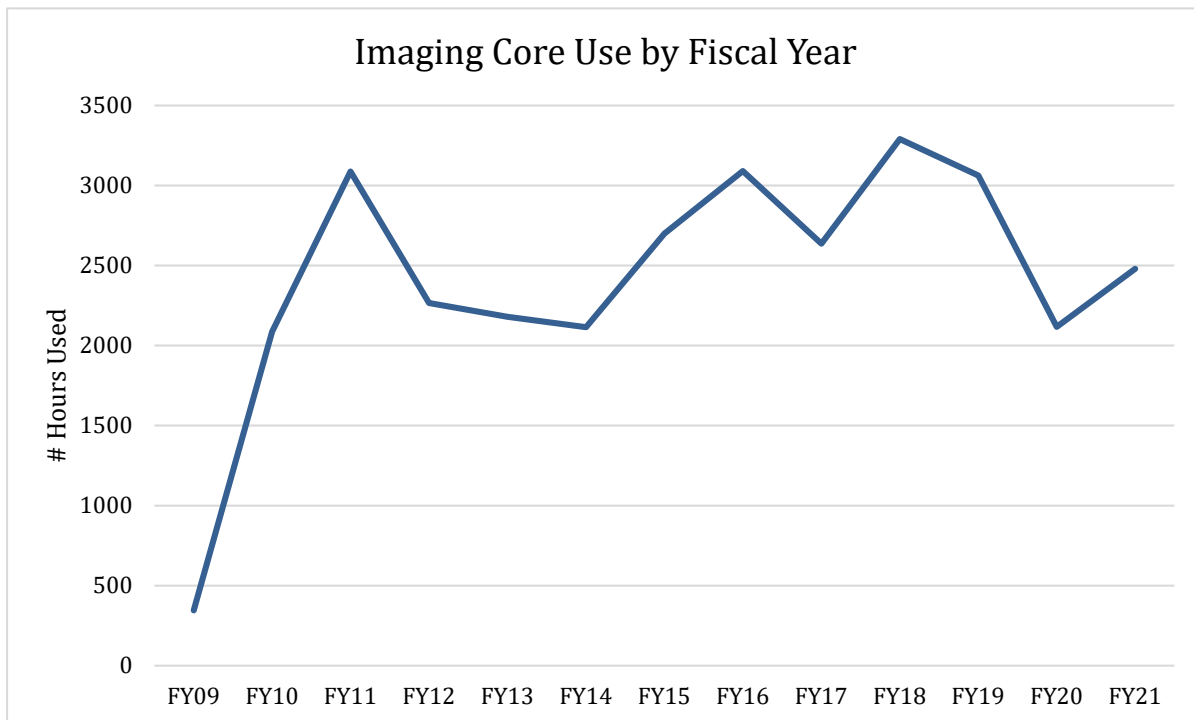


Figure 2: Top Microscope Users by Department FY21

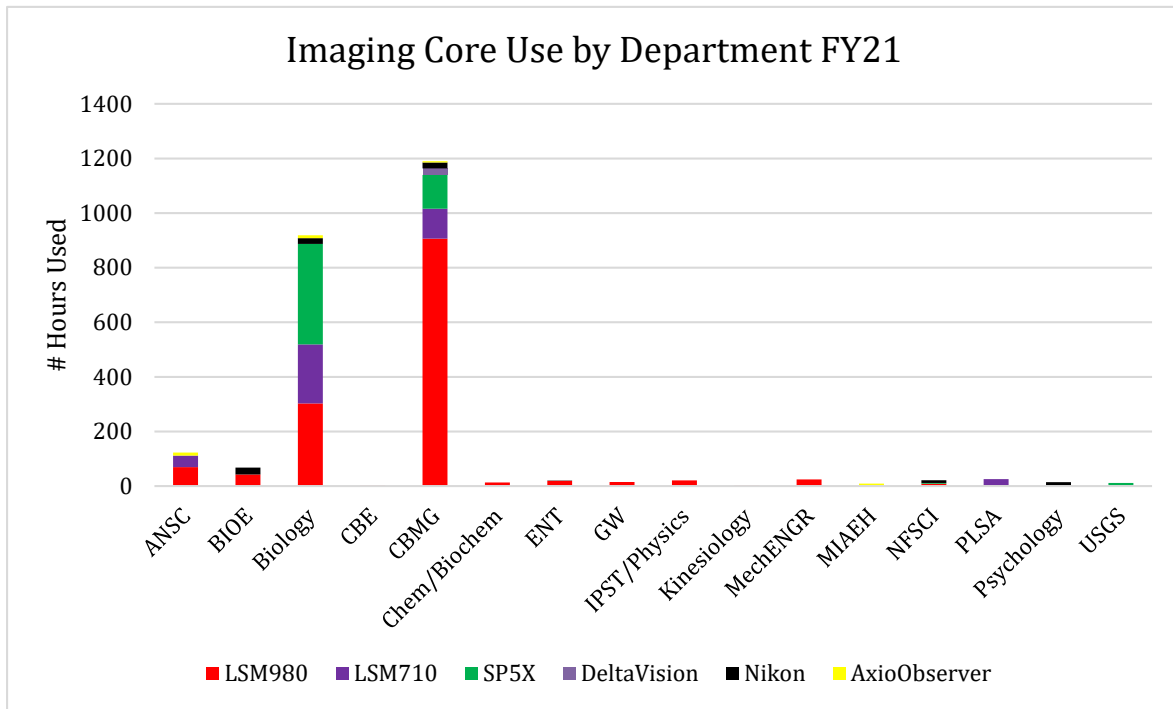


Figure 3: Top Microscope Users FY21

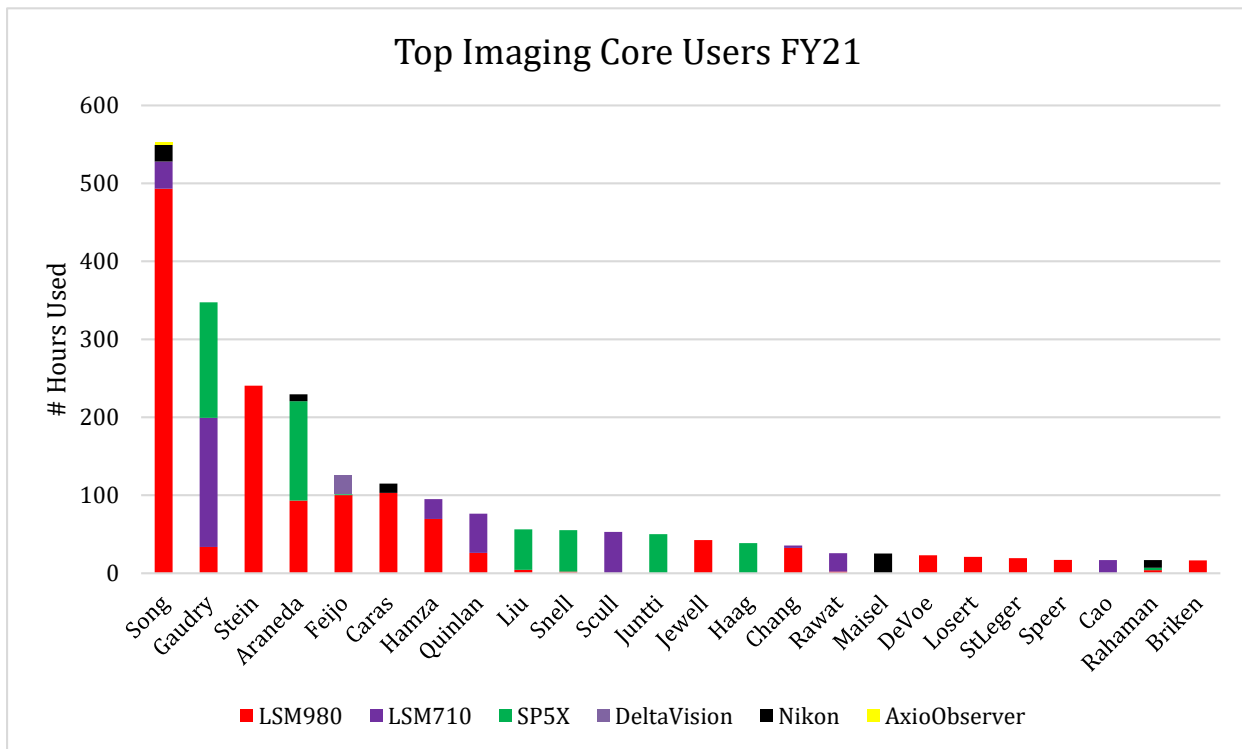
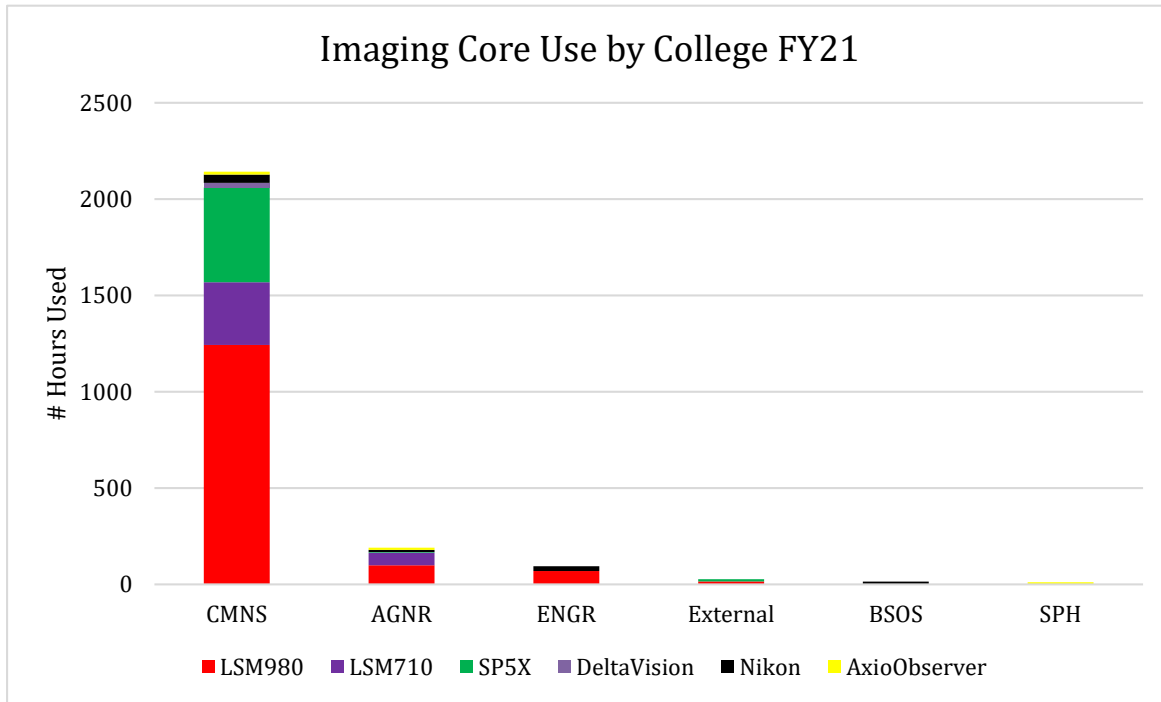


Figure 4: Imaging Core Use by College FY21



Operating Cost Analysis

In FY21 revenue exceeded expenses by \$5,019. This was only possible because the Zeiss LSM980 service contract was prepaid for 2 years at the time of purchase.

Table 8: FY21 Income and Expenses by Microscope

Instrument/ Source Income	Service contract cost	Consumable Cost	Total Expenses	Income	Income - Expenses
Zeiss LSM 980	\$24,623	\$257	\$257	\$39,039	\$45,638
Zeiss LSM 710	\$18,859	\$257	\$19,116	\$12,403	(\$6,457)
Leica SP5 X	\$33,675	\$257	\$33,932	\$15,458	(\$18,474)
DeltaVision	\$9,934	\$257	\$10,191	\$720	(\$9,471)
Zeiss Observer	\$0	\$257	\$257	\$353	\$95
Nikon Eclipse	\$0	\$257	\$257	\$1,059	\$802
Total	\$62,468	\$1,543	\$64,011	\$69,030	\$5,019

Table 9: Total Imaging Core Facility Income and Expenses from FY09-FY20

Year	Total Income from Charge-backs	Total Imaging Core Expenses	Net Balance
FY2009	\$5,091	\$6,113	(\$1,023)
FY2010	\$30,732	\$29,564	\$1,169
FY2011	\$57,738	\$55,525	\$2,214
FY2012	\$49,778	\$76,562	(\$26,685)
FY2013	\$55,810	\$59,673	(\$3,862)
FY2014	\$57,184	\$59,876	(\$2,692)
FY2015	\$60,303	\$73,955	(\$13,652)
FY2016	\$79,028	\$75,544	\$3,484
FY2017	\$71,458	\$80,234	(\$8,784)
FY2018	\$100,126	\$69,261	\$30,864
FY2019	\$94,673	\$69,097	\$25,967
FY2020	\$64,641	\$71,083	-\$6,442
FY2021	\$69,030	\$64,011	\$5,019
Total	\$795,593	\$790,504	\$5,088

Table 10: Cost Breakdown: Leica SP5X

Year	Service Contract Cost	Consumable Expenses	Total Expenses	Income	Income - Expenses*
FY2009	0	\$6,113	\$6,113.25	\$5,091	(\$1,023)
FY2010	\$26,000	\$2,376	\$28,375.80	\$18,363	\$27,487
FY2011	\$36,075	\$488	\$36,563.25	\$24,290	\$25,227
FY2012	\$52,296	\$2,056	\$54,351.56	\$21,882	\$5,032
FY2013	\$37,092	\$1,887	\$38,979.16	\$21,922	(\$17,057)
FY2014	\$37,092	\$1,015	\$38,106.42	\$25,160	(\$12,290)
FY2015	\$37,743	\$51	\$37,794.49	\$25,576	(\$12,218)
FY2016	\$37,743	\$609	\$38,352.00	\$35,865	(\$2,487)
FY2017	\$39,630	\$616	\$40,245.64	\$33,158	(\$7,088)
FY2018	\$39,630	\$96	\$39,726.42	\$49,600	\$9,873
FY2019	\$36,850	\$707	\$37,556.46	\$39,378	\$1282
FY2020	\$36,849	\$730	\$37,579	\$20,995	(\$16,584)
FY2021	\$33,675	\$257	\$33,932	\$335,382	(\$18,474)
Total	\$450,673	\$17,002	\$467,676	\$319,925	(\$132,293)

*Does not include matching funds for years 2-3 service contracts

Table 11: Cost Breakdown: LSM710

Year	Service Contract Cost	Consumable Expenses	Total Expenses	Income	Income - Expenses
FY2009	\$0	\$0	\$0	\$0	\$0
FY2010	\$0	\$1,188	\$1,188	\$12,370	\$11,182
FY2011	\$17,730	\$1,232	\$18,962	\$33,448	\$14,487
FY2012	\$19,260	\$2,951	\$22,211	\$27,896	\$5,685
FY2013	\$19,260	\$1,434	\$20,694	\$33,889	\$13,195
FY2014	\$19,260	\$360	\$19,620	\$31,471	\$12,211
FY2015	\$19,755	\$51	\$19,806	\$27,655	\$7,848
FY2016	\$19,755	\$608	\$20,363	\$32,847	\$12,484
FY2017	\$19,969	\$785	\$20,754	\$26,055	\$5,301
FY2018	\$19,969	\$96	\$20,066	\$35,400	\$15,334
FY2019	\$19,969	\$707	\$20,676	\$42,551	\$21,875
FY2020	\$19,969	\$856	\$20,825	\$28,689	\$7,864
FY2021	\$18,859	\$257	\$19,116	\$12,403	-\$6,457
Total	\$194,897	\$10,267	\$205,163	\$332,270	\$121,010

Table 12: Cost Breakdown: DeltaVision

Year	Service Contract Cost	Consumable Expenses	Total Expenses	Income	Income - Expenses
FY2014	\$0	\$739	\$739	\$318	(\$422)
FY2015	\$16,200	\$51	\$16,251	\$6,155	(\$10,097)
FY2016	\$16,200	\$323	\$16,523	\$6,824	(\$9,700)
FY2017	\$17,461	\$160	\$17,621	\$7,267	(\$10,354)
FY2018	\$9,180	\$96	\$9,276	\$12,674	\$3,397
FY2019	\$9,450	\$707	\$10,157	\$8,611	(\$1,546)
FY2020	\$9,720	\$171	\$9,891	\$4,517	(\$5,374)
FY2021	\$9,934	\$257	\$10,191	\$720	(\$9,471)
Total	\$88,145	\$2,505	\$90,650	\$47,084	(\$43,566)

Projected Cost Analysis:

Based on the available balance in the IC revolving account, the IC will be able to maintain service contracts on all the instruments through FY22. Beginning on 4/30/22 and 12/2/2022, neither the Zeiss LSM710 and Leica SP5x will be eligible for service contract renewals. The companies will stop making replacement parts for the instruments at this time.

If the IC is to remain competitive, solvent, and self-sustaining, the director suggests we keep the LSM980 rates unchanged but reinstate the normal training fee (\$150 per person).

Proposed Rate Schedule:

A thorough examination of confocal microscope rates at other institutions (Appendix 5) shows that the facility’s confocal peak rates are priced slightly lower than the average rate of \$37/hour, and the DeltaVision’s rates are on par with the average. The IC continues to offer highly competitive, low-priced off-peak rates of \$24/hr. The director suggests keeping these rates the same in FY22.

Table 12: Suggested Imaging Core Rates for Academic Year 2021 - 2022

Instrument	UMD Users	External Users
Zeiss LSM 980	\$28/hr peak \$22/hr off-peak	N/A
Leica SP5X, Zeiss LSM710, PerkinElmer Spinning Disk, Hourly Rate for Unassisted Use	\$34/hr peak \$24/off-peak	\$85/hr
DeltaVision Hourly Rate for Unassisted Use	\$30/hr peak \$24/hr off-peak	\$85/hr
Leica SP5X, Zeiss LSM710, DeltaVision, PerkinElmer Spinning Disk 14 hour overnight flat fee, 6pm-8am, M-F	\$150	Inquire
Leica SP5X, Zeiss LSM710, DeltaVision, PerkinElmer Spinning Disk 12 hour day rate (flat fee), 8am-8pm, M-F	\$250	Inquire
Leica SP5X, Zeiss LSM710, DeltaVision, PerkinElmer Spinning Disk 24 hour rate (flat fee), M-F	\$350	Inquire
Leica SP5X, Zeiss LSM710, DeltaVision, PerkinElmer Spinning Disk 24 hour rate (flat fee), Weekend Rate	\$200	Inquire
Leica SP5X, Zeiss LSM710, DeltaVision, PerkinElmer Spinning Disk 48 hour rate (flat fee), Weekend Rate	\$400	Inquire
Leica SP5 X, Zeiss LSM 710, DeltaVision, PerkinElmer Spinning Disk Hourly Rate for Assisted Use	\$50/hr	\$180/hr
Leica SP5X, Zeiss LSM 710, DeltaVision, PE Training Fee (per person)	\$150	\$300
Zeiss AxioObserver, Axiophot and Nikon Eclipse Hourly Rate for Unassisted Use	\$10/hr	\$40/hr
Zeiss AxioObserver, Axiophot and Nikon Eclipse Training Fee (per person)	\$25	\$100

Appendix 1: Past Imaging Core Rates

Equipment	Location	Purchase and/or Installation Date	In-College Rate History (Academic Year)
Zeiss LSM 980 Airyscan 2 Confocal Microscope	0105 MICB	Installed 11/15/19	2019-2021: \$28/hr Peak; \$22/hr Off-Peak
Zeiss LSM 710 Confocal Microscope	0107E MICB	October 2009 (Purchased by CBMG/CMNS)	2009/2010: \$15.00/hr 2010/2011: \$18.60/hr 2011/2012: \$22.00/hr 2012/2013: \$26.00/hr Peak; \$23.00/hr Off-Peak 2013/2014: \$26.00/hr Peak; \$23.00/hr Off-Peak 2014/2015: \$28.00/hr Peak; \$24.00/hr Off-Peak 2015/2016: \$32.00/hr Peak; \$22.00/hr Off-Peak 2016/2017: \$32.00/hr Peak; \$22.00/hr Off-Peak 2018-2020: \$34.00/hr Peak; \$24.00/hr Off-Peak
Leica SP5X Confocal Microscope	0107H MICB	December 2008 (Purchased via NSF MRI grant)	2008/2009: \$15.00/hr 2009/2010: \$15.75/hr 2010/2011: \$18.60/hr 2011/2012: \$22.00/hr 2012/2013: \$26.00/hr Peak; \$23.00/hr Off-Peak 2013/2014: \$26.00/hr Peak; \$23.00/hr Off-Peak 2014/2015: \$28.00/hr Peak; \$24.00/hr Off-Peak 2015/2016: \$32.00/hr Peak; \$22.00/hr Off-Peak 2016/2017: \$32.00/hr Peak; \$22.00/hr Off-Peak 2018-2020: \$34.00/hr Peak; \$24.00/hr Off-Peak
Deltavision Deconvolution/ TIRF Microscope	0107F MICB	March 2014 (Purchased by CBMG)	2013/2014: \$10/hr 2014/2015: \$10/hr thru 3/2015 2014/2015: \$28.00/hr Peak; \$24.00/hr Off-Peak 2015/2016: \$28.00/hr Peak; \$22.00/hr Off-Peak 2016/2017: \$28.00/hr Peak; \$22.00/hr Off-Peak 2017/2018: \$30.00/hr Peak; \$24.00/hr Off-Peak 2018-2020: \$34.00/hr Peak; \$24.00/hr Off-Peak
Zeiss AxioObserver Fluorescence	0107K	February 2014 (Relocated from BRB; originally purchased by CBMG)	2013 to 2017: \$5/hr 2/1/18: \$10/hr 2018-2020: \$10/hr
Nikon Eclipse	0107B	October 2017 (relocated)	2016/2017: \$5/hr 2/1/18: \$10/hr 2018/2019: \$10/hr
PerkinElmer confocal spinning disk	B0118 PSC	December 2014 (purchased by Physics for PSC)	2014/2015: \$28.00/hr Peak; \$24.00/hr Off-Peak 2015/2016: \$32.00/hr Peak; \$22.00/hr Off-Peak 2016/2017: \$32.00/hr Peak; \$22.00/hr Off-Peak 2/1/18: \$34.00/hr Peak; \$24.00/hr Off-Peak 2018/2019: \$34.00/hr Peak; \$24.00/hr Off-Peak

Appendix 2: Summary of changes in IC instrumentation since November 2005

- 8/2006: A Mini Med 90 Film Processor (cost: \$3,588.00) replaced the old Konica processor. The department paid \$2,500.00 of the total cost and each of the following PIs contributed \$109: Jonathan Dinman, Jeffrey DeStefano, Kenneth Frauwirth, David Mosser, Anne Simon, Wenxia Song, Richard Stewart and Elizabeth Gantt.
- 10/2006: Dr. Steve Wolniak (Interim Chair of CBMG) procured a Zeiss Axiophot fluorescence microscope for the facility following Dr. Ron Weiner's retirement. A CoolSnap EZ monochrome camera, computer workstation and Nikon Elements software (total cost: \$13,400.00) were purchased in 2007 for the microscope using CBMG funds.
- 4/2007: The 7700 Sequencer Detector was replaced with a Roche LightCycler 480 Real-Time PCR machine, which was purchased by CBMG using the Bioscience Research Building capital equipment funds (and is housed in BRB; see below).
- 8/2007: Due to a drop in usage, the 3100 North DNA sequencer was taken out of operation.
- 12/2008: The instruments in 0107H MICB (two ABI 3100 DNA sequencers, the ABI 3730xl DNA Sequencer and the Roche LightCycler 480 Real-Time PCR machines) were moved to the new Genomics Core, room 2229 Bioscience Research Building.
- 12/2008: The Leica SP5 X confocal microscope was installed in room 0107H MICB. This microscope was obtained by Drs. Ian Mather and Steve Wolniak via an NSF MRI grant.
- 10/2009: The LSM510 confocal microscope was dismantled to make way for the new Zeiss LSM710, which was purchased using college funds, authorized by Dean Allewell.
- 1/2009: Genomics Core Equipment: Bio-Rad CFX 96 Real-time PCR machine was purchased and placed in room 2229 BRB.
- 4/2010: Genomics Core Equipment: Due to a drop in usage, the 3100 "West" DNA sequencer was taken out of operation.
- 7/2011: Genomics Core Equipment: July 2011: Both the 3100 "West" and 3100 "North" DNA sequencers were sold through Terrapin Trader.
- 11/2011: A Thermo Scientific Midi 40 CO2 incubator was purchased using IC funds (\$3,194.00).
- 2/2014: a Zeiss AxioObserver widefield fluorescence microscope was relocated from room 3207 Bioscience Research Building. The microscope was installed in room 0107K and upgraded with a new computer, new software (Zen 2012) and a new power supply, using a combination of departmental and IC funds.
- 3/2014: A DeltaVision Deconvolution/TIRF microscope was installed in room 0107F MICB. The microscope was purchased with departmental and college funds.
- 4/2014: Financial responsibility for the DNA sequencer was transferred to the Biology Dept.
- 8/2014: The Leica SP5 X was upgraded with a new HyD detector and time-gating technology.
- 10/2014: The Zeiss LSM 710 computer was replaced (free upgrade due to computer issues with the old operating system) with a Windows 7 computer and the software was upgraded to the latest version of Zen.
- 12/2014: A PerkinElmer spinning disk confocal microscope was installed in the Satellite Core, room B0118 Physical Sciences Complex.
- 1/2015: As a result of increased Imaging Core responsibilities, management of the Genomics Core was transferred from Amy Beaven to Dr. Yan Wang.
- 7/24/15: The Mini Med 90 Film Processor was taken out of service. It was decontaminated by DES (Cleveland Taylor) and sent to Terrapin Trader.
- 2/2016: The IC implemented a new BSL-2 protocol to allow imaging of approved BSL-2 samples.

- 4/2016: Dr. Charles Delwiche purchased 4 new objective lenses for the DeltaVision and loaned them to the IC: 10x 0.4 NA, 20x 0.75NA, 40x 0.6NA LWD and 40x 1.3NA oil lens.
- 10/2016: A Nikon Eclipse transferred from Dr. Nicole Li's old lab on the 3rd floor of MICB to the IC, room 0107A MICB.
- 4/2017: the ASI diSPIM lighsheet microscope was installed in B0118 PSC on April 4-5 (ahead of the purchase order issued on April 27, 2017).
- 5/2017: The IC acquired room 0105 MICB. The LightCycler 480 qPCR machine was transferred from 2229 BRB to this space, and the Director of the IC now manages the instrument (again).
- 10/7/17: Old DeltaVision Nikon microscope moved to Imaging Incubator in PSC. To be incorporated in the JPK NanoWizard 4a BioAFM.
- 10/16 – 10/18/2017: JPK NanoWizard 4a BioAFM installed (purchase order issued 8/18/17).
- 11/9/2017: Launched new website: <http://biosciencecores.umd.edu/>
- 11/2/2018: The Covaris Ultrasonicator installed in 0107A (transferred from Antony Jose's lab; originally from the IBBR Sequencing Core)
- 5/28/2019: A new Agilent TapeStation was installed in room 0107L MICB.
- 11/15/2019: Zeiss LSM 980 Airyscan 2 installed in 0105 MICB.

Appendix 3: Imaging Equipment on Campus

Equipment	Purchase/Installation Date	Owner (purchased by...)	Location	Available to anyone in CBMG?
Zeiss LSM980 Airyscan 2	11/15/20	CBMG/NIH S10 (PI: Beaven)	CBMG Imaging Core: 0105 MICB	Yes
Zeiss LSM710 Confocal	10/2009	CBMG/CMNS	CBMG Imaging Core: 0107E MICB	Yes
Leica SP5X Confocal	12/2008	ANSC/CBMG (Purchased via NSF MRI grant)	CBMG Imaging Core: 0107H MICB	Yes
Deltavision Deconvolution/TIRF Microscope	3/2014	CBMG	CBMG Imaging Core: 0107F MICB	Yes
Zeiss AxioObserver Fluorescence	2/2014	CBMG (Relocated from BRB in 2014)	CBMG Imaging Core: 0107K	Yes
Axiophot Brightfield Microscope	7/2007	CBMG (Camera and software)	CBMG Imaging Core: Main lab	Yes
Nikon Eclipse w/color camera	10/2017	CBMG (relocated from Li lab)	CBMG Imaging Core: 0107B	Yes
PerkinElmer confocal spinning disk	12/2014	CMNS (purchased with PSC building funds)	CMNS Imaging Incubator: B0118 PSC	Yes
ASI diSPIM Lighsheet	4/2017	CMNS (purchased w/PSC building funds)	CMNS Imaging Incubator: B0118 PSC	Yes
JPK NanoWizard 4a BioAFM	10/2017	CMNS (purchased with PSC building funds)	CMNS Imaging Incubator: B0118 PSC	Yes
Andor Spinning Disk	August 2016	Sougata Roy (CBMG)	Roy Lab, BRB	No
Zeiss LSM700	~July 2012	IBBR/BioENGR	5131A PLS building	No
Zeiss LSM700 Confocal	Transferred in FY17 from S. Wolniak	Margaret Scull (CBMG)	Scull lab, BRB	No
Zeiss LSM 800 Airyscan Confocal	FY16	Lisa Taneyhill	Taneyhill lab, ANSC	No
Zeiss LSM710	~FY14	Murphy/Peer	Murphy/Peer lab, PLS	No
PerkinElmer Spinning Disk	FY08	Norma Andrews (CBMG)	Andrews lab, BRB	No
Olympus confocal	FY18	BioWorkshop	BioEngineering	Yes

Appendix 4: Publications

Publications that entailed the use of the LSM 980 (to date):

1. Hoffmann, R.D., Portes, M.T., Olsen, L.I., Damineli, D.S., Hayashi, M., Nunes, C.O., Pedersen, J.T., Lima, P.T., Campos, C., Feijo, J.A., Palmgren, M. Plasma membrane H⁺-ATPases sustain pollen tube growth and fertilization. *Nat Commun* **11**, 2395 (2020). <https://doi.org/10.1038/s41467-020-16253-1>
2. Rastogi S, Ellinwood S, Augenstreich J, Mayer-Barber KD, Briken V (2021) *Mycobacterium tuberculosis* inhibits the NLRP3 inflammasome activation via its phosphokinase PknF. *PLoS Pathogens* 17(7): e1009712. <https://doi.org/10.1371/journal.ppat.1009712>

Publications that entailed the use of the Leica SP5 X (to date):

1. Sikes, J. M. and Bely, A. E. (2008), Radical modification of the A–P axis and the evolution of asexual reproduction in *Convolutriloba* acoels. *Evolution & Development*, 10: 619–631. doi: 10.1111/j.1525-142X.2008.00276.x
2. Sikes, J.M. and Bely, A.E. (2009), Making heads from tails: Development of a reversed anterior-posterior axis during budding in an acoel. *Devel. Biol.* 338 (1): 86-97.
3. Hou, H.Y., Heffer, A., Liu, J., Anderson, W.R., Liu, J., Bowler, T. and Pick, L. (2009) Stripy Ftz target genes are coordinately regulated by Ftz-F1. *Dev. Biol.* 335:442-453.
4. Zhang, H., Liu, J., Li, C.R., Momen, B., Kohanski, R.A. and Pick, L. (2009). A fly model for diabetes: deletion of *Drosophila* Insulin-Like peptides causes growth defects and metabolic abnormalities. *Proc. Natl. Acad. Sci. U S A.* 106:19617-22.
5. Jammes, F., Song, C. J., D. Shin, Munemasa, S., Takeda, K., Gu, D., Cho, D. S., Lee, S., Giordo, R., Sritubtim, S., Leonhardt, N., Ellis, E. B., Murata, Y. and Kwak, J. M. (2009) Two MAP kinases, MPK9 and MPK12, are preferentially expressed in guard cells and positively regulate ROS-mediated ABA signaling. *Proc. Nat'l. Acad. Sci. USA*, 106: 20520-20525.
6. Kong, D., Cho, D. S., Hu, H.-C., Li, J., Lazzaro, M., Lee, S., Jeon, B.-W., Munemasa, S., Murata, Y., Nam, H. G, Pei, Z.-M. and Kwak, J. M. (2010) Arabidopsis glutamate receptor homologs form Ca²⁺-permeable cation channels and contribute to Ca²⁺ uptake. Submitted.
7. Cho, D.S., Villiers, F., Kroniewicz, L., Lee, S., Zhao, J., Hirschi, K., Leonhardt, N. and Kwak, J. M. (2010) CAX1 and CAX3 contribute to the regulation of cytosolic pH and function in crosstalk between auxin and ABA in guard cells. In preparation.
8. Bely, A.E. and J.M. Sikes (2010). Latent regeneration abilities persist following recent evolutionary loss in asexual annelids. *Proceedings of the National Academy of Sciences* 107:1464-1469.
9. Flannery, A, Czibener, C. and Andrews, N.W. (2010) Palmitoylation-dependent association with CD63 targets the Ca²⁺ sensor synaptotagmin VII to lysosomes. *J. Cell Biol.* 191:599-613.
10. Severance S, Rajagopal A, Rao AU, Cerqueira GC, Mitreva M, El-Sayed NM, Krause M, Hamza I. "Genome-wide analysis reveals novel genes essential for heme homeostasis in *Caenorhabditis elegans*," *PLoS Genet*, v.6, 2010, p. e1001044.
11. Sinclair J.; Hamza I. "A novel heme-responsive element mediates transcriptional regulation in *Caenorhabditis elegans*," *J. Biol. Chem.*, v.285, 2010, p. 39536.
12. Zattara, E.E. and A.E. Bely (2011). Evolution of a novel developmental trajectory: fission is distinct from regeneration in the annelid *Pristina leidyi*. *Evolution & Development* 13:80-95.
13. Cortez, M., Huynh, C., Fernandes, M.C., Kennedy, K.A., Aderem, A. and Andrews, N.W. (2011) *Leishmania* promotes its own virulence by inducing expression of host CD200. *Cell Host & Microbe* 9:463-471. Highlight in *Nature Reviews Microbiology*

14. Fernandez, M.C., Cortez, M., Flannery, A.R., Tam, C., Mortara, R.A. and N.W. Andrews. (2011) Trypanosoma cruzi subverts the sphingomyelinase-mediated plasma membrane repair pathway for cell invasion. *J. Exp Med.* 208(5): 909-21.
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16. Huang J, Wang Y, Raghavan S, Feng S, Kiesewetter K, Wang J. (2011) Human down syndrome cell adhesion molecules (DSCAMs) are functionally conserved with *Drosophila* Dscam^[TM1] isoforms in controlling neurodevelopment. *Insect Biochem Mol Biol.* [Epub ahead of print]
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20. Kendall E, Shao C and Don L. DeVoe. Formation of asymmetric folded bilayers by lipid bubble injection in a thermoplastic microfluidic chip. Accepted to *Small*.
21. Shao, C., Kendall E and Don L. DeVoe. Electro-optical BLM chips enabling dynamic imaging of ordered lipid domains. Accepted by *Lab on a Chip*.
22. Chau Huynh, Yuan, X., Miguel, D., Renberg, R., Protchenko, O., Philpott, C., Hamza, I., and Andrews, N. (2012) Heme uptake by *Leishmania amazonensis* is mediated by the transmembrane protein LHR1. *PLoS Pathogens.* 8:7:e1002795.
23. A DEAD box RNA helicase is critical for pre-mRNA splicing, cold-responsive gene regulation, and cold tolerance in Arabidopsis. Guan Q, Wu J, Zhang Y, Jiang C, Liu R, Chai C, Zhu J. *Plant Cell.* 2013 25(1):342-56. doi: 10.1105/tpc.112.108340. PMID:23371945
24. A KH domain-containing putative RNA-binding protein is critical for heat stress-responsive gene regulation and thermotolerance in Arabidopsis. Guan Q, Wen C, Zeng H, Zhu J. *Mol Plant.* 2013 6(2):386-95. doi: 10.1093/mp/sss119.PMID:23087326
25. A Bi-functional Xyloglucan Galactosyltransferase is an indispensable salt stress tolerance determinant in Arabidopsis. Li W, Guan Q, Wang ZY, Wang Y, Zhu J. *Mol Plant.* 2013 Jun 22. PMID:23571490
26. Analyzing actin dynamics during the activation of the B cell receptor in live B cells. Liu C, Miller H, Sharma S, Beaven A, Upadhyaya A, Song W. *Biochem Biophys Res Commun.* 2012 Oct 12;427(1):202-6. doi: 10.1016/j.bbrc.2012.09.046. Epub 2012 Sep 17. PMID: 22995298
27. Chunying Kang, Omar Darwish, Aviva Geretz, Rachel Shahan, Nadim Alkharouf, and Zhongchi Liu Genome-Scale Transcriptomic Insights into Early-Stage Fruit Development in Woodland Strawberry *Fragaria vesca*. *Plant Cell* 2013 tpc.113.111732; First Published on June 28, 2013; doi:10.1105/tpc.113.111732
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Other accomplishments that entailed the use of the Leica SP5 X:

1. Eduardo E. Zattara: Winner of 2016 American Microscopical Society Ralph and Mildred Buchsbaum Prize for Excellence in Photomicrography Color division https://www.researchgate.net/publication/296699445_Winner_of_the_2016_American_Microscopical_Society_Ralph_and_Mildred_Buchsbaum_Prize_for_Excellence_in_Photomicrography_Color_division?ev=prf_pub
2. Venuti, L. S.; Swierzbinski, M.E., & Herberholz, J. (2014, November). *Investigation of fast autoinhibition in the lateral giant circuit of crayfish*. Poster session presented at the meeting of the Society for Neuroscience, Washington D.C.
3. Van Goor, J. and Haag, E. "Exploring the mechanisms of MSS-mediated sperm competition in *C. briggsae*". Virtual oral presentation for the Evolution of *Caenorhabditis* and other Nematodes Meeting (June 25, 2020)
4. Van Goor, J. and Haag, E. "Exploring the mechanisms of MSS-mediated sperm competition in *C. briggsae*". Virtual oral presentation at the Cold Spring Harbor Germ Cells Meeting (October 2, 2020)
5. Van Goor, J. "Sex ratio allocation in nematodes: divergent avenues for securing evolutionary persistence". Invited virtual seminar presentation at Western Colorado University (March 26, 2021)
6. Van Goor, J. and Haag, E. "Exploring the mechanisms of MSS-mediated sperm competition in *C. briggsae*". Virtual poster presentation for the 23rd International *C. elegans* Conference (June 23, 2021).
7. Van Goor, J. and Haag, E. "Exploring the mechanisms of MSS-mediated sperm competition in *C. briggsae*". Virtual oral presentation for Evolution 2021 (June 23, 2021).

Publications that entailed the use of the LSM710 (to date):

1. Roy V., Smith J.I., Wang J., Stewart J.E., Bentley W.E. & Sintim H.O. (2010) Synthetic analogs tailor native AI-2 signaling across bacterial species. *Journal of the American Chemical Society*, 132 (32), pp 11141–11150
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Appendix 5: Example Rates at Other Institutions

Confocal Rates (updated July 2019)

Facility	Instrument	Hourly Rate
Berkeley Biological Imaging Facility	Zeiss LSM 710	\$ 40.00
Cornell University Life Sciences Imaging	Zeiss LSM 710	\$ 35.00
University of Virginia School of Medicine	LSM880	\$ 45.00
Northwestern University Biological	Leica SP5	\$ 39.00
Northwestern University Biological	Zeiss LSM 510	\$ 40.00
Arizona State Imaging Facility	Leica SP5	\$ 25.00
Arizona State Imaging Facility	Leica SP8	\$ 35.00
Duke University Light Microscopy Core	Leica SP5	\$ 30.00
Duke University Light Microscopy Core	Zeiss LSM 780	\$ 30.00
Michigan State U Center Advanced	Zeiss LSM 510	\$ 25.00
Michigan State U Center Advanced	Olympus FV 1000	\$ 25.00
University of Washington Keck Facility	Zeiss LSM 510	\$ 45.00
University of Connecticut	Leica SP8	\$ 15.00
UVA Keck Center	Zeiss LSM 510	\$ 35.00
UVA Keck Center	Leica SP5X	\$ 35.00
Oregon State University	Zeiss LSM 780	\$ 30.00
Oregon State University	Zeiss LSM 780	\$ 26.00
Yale School of Medicine	Leica SP5	\$ 50.00
Texas A&M	Olympus FV 1000	\$ 42.00
Boise State University	Zeiss LSM 510	\$ 19.59
Rockefeller University	Leica SP8	\$ 56.00
Notre Dame	Nikon A1	\$ 31.00
Washington University in St. Louis	Nikon A1	\$ 32.00
Perlman School of Medicine	Zeiss LSM 710	\$ 42.00
University of California, Davis	Olympus FV 1000	\$ 35.00
UC Santa Cruz	Leica SP5	\$ 25.00
Indiana University	Leica SP5	\$ 19.75
Indiana University	Leica SP8	\$ 21.75
U of Georgia Biomedical Microscopy Core	Zeiss LSM 710	\$ 50.00
University of Illinois at Chicago	Zeiss LSM 710	\$ 45.00
University of Illinois at Chicago	Zeiss LSM 710 Meta	\$ 41.00
University of Illinois Urbana-Champaign	Zeiss LSM 710	\$ 35.00
University of Illinois Urbana-Champaign	Zeiss LSM 880	\$ 44.00
UC San Diego	Olympus FV 1000	\$ 36.00
Baylor College of Medicine	LSM880	\$ 35.00
Baylor College of Medicine	LSM780 Fast	\$ 35.00
Baylor College of Medicine	Leica SP8	\$ 35.00
University of North Carolina Chapel Hill	Zeiss LSM 710	\$ 35.90
University of Chicago	Leica SP8	\$ 42.44
University of Chicago	Leica SP5	\$ 42.44
Virginia Commonwealth University	Zeiss LSM 710	\$ 20.00
Massachusetts Institute of Technology	Olympus FV 1000	\$ 40.00
Georgia Tech	Zeiss LSM 710	\$ 16.00
NYU Langone Health	Leica SP5	\$ 55.00
NYU Langone Health	Zeiss LSM 880	\$ 65.00
University of Minnesota	LeicaSP5	\$ 52.50
University of Minnesota	Nikon A1	\$ 52.50
U of Missouri	LeicaSP8	\$ 35.00
Albert Einstein College of Medicine	LeicaSP5	\$ 43.00
Albert Einstein College of Medicine	LeicaSP8	\$ 43.00
Average Hourly Rate		\$ 37.00

DeltaVision Rates (updated July 2019)

Facility	Instrument	Hourly Rate
Berkeley Biological Imaging Facility	DeltaVision	\$ 37.00
Northwestern University Biological Imaging	DeltaVision	\$ 25.00
Duke University Light Microscopy Core	DeltaVision Elite	\$ 17.00
Rockefeller University	DeltaVision	\$ 42.00
Notre Dame	DeltaVision	\$ 19.00
University of California, Davis	DeltaVision	\$ 35.00
Indiana University	DeltaVision	\$ 16.50
U of Georgia Biomedical Microscopy Core	DeltaVision	\$ 35.00
University of Arizona Microscopy Alliance	DeltaVision	\$ 35.00
University of Arizona Microscopy Alliance	DeltaVision	\$ 25.00
UC San Diego	DeltaVision	\$ 28.00
University of Michigan Medical School	DeltaVision	\$ 20.00
Massachusetts Institute of Technology	DeltaVision	\$ 40.00
Koch Institute at MIT	DeltaVision	\$ 40.00
Average Hourly Rate		\$ 30.00

Widefield Fluorescence Microscope Rates (updated July 2019)

Facility	Instrument	Hourly Rate
Cornell University Life Sciences Imaging Core	Olympus Widefield	\$ 15.00
University of Washington Keck Facility	Widefield	\$ 22.00
UVA Keck Center	Widefield	\$ 15.00
UC Santa Cruz	Zeiss Axioskop	\$ 8.00
University of Illinois Urbana-Champaign	Zeiss Widefield	\$ 22.00
Perlman School of Medicine	Zeiss Observer	\$ 20.00
Average Hourly Rate		\$ 17.00