

# Imaging Core Annual Report FY2017

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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 FY17 alone, 41 laboratories from 13 departments across 3 colleges (CMNS, AGNR, ENGR) used the facility's high-end light microscopes, as did undergraduate and graduate students in the course BSCI427/CBMG688W (Principles of Microscopy), undergrads in the FIRE program, and attendees of the international Pollen Network Workshop (hosted by the IC, April 5-10,). During the past year, the Director trained 71 new researchers to independently operate the IC's microscopes, bringing the total number of trained users since FY05 to 737. Access to the facility's microscopes and high-quality training has directly resulted in at least 148 publications (see Appendix 4).

Though the IC remains an invaluable resource, the facility saw a 21% drop in use in FY17. This can partly be attributed to a 62% decrease in confocal use by Dr. Roy, who purchased his own spinning disk in August 2016. Coincidentally, this is the same month his start-up agreement for free and reduced time on IC instruments expired. While use of the DeltaVision Deconvolution/TIRF remained at FY16 levels, the AxioObserver fluorescence scope saw a 61% increase in use. This scope allowed new CBMG faculty member Dr. Scull to run preliminary experiments prior to the arrival of her laboratory's own microscope, and provided ~20 FIRE students with access to a basic fluorescence scope for their research projects. Finally, although the Nikon Eclipse was only just acquired in October 2016, several images taken with its color camera have already been included in a publication (Du et al., 2017).

In FY17, expenses for all IC microscopes exceeded the total income collected via charge-backs by **\$8,783.50**. If rates remain unchanged and microscope use stays at FY17 levels, the IC account balance will fall below zero in December 2020 (Figure 5). It should be noted that between FY11-17, CBMG faculty members Cao, Jose, and Roy received \$26,659 in free microscope time as a part of start-up agreements with CBMG. In addition, Principles of Microscopy students received \$20,706 in free training and microscope time between FY10-17. Had the IC received this revenue (\$46,365 in total), the account would have been expected to remain above zero (Figure 6) until December 2022.

Looking to the future, the IC's two confocals (purchased in 2008 and 2009) will become obsolete in 2-3 years. Meanwhile, the number of new, high-end microscopes on campus has steadily been increasing, in part due to the IC Director's involvement in the acquisition, management, and installation of the PerkinElmer spinning disk, ASI diSPIM lightsheet, and JPK AFM systems for the newly establish Imaging Incubator. If the IC is to remain competitive, solvent, and self-sustaining, the Director suggests we take the following actions:

1. Obtain funding for a new, state-of-the-art, confocal microscope. The Director has already started this process by submitting an NIH S10 Shared Instrumentation Grant in May 2017 for a Zeiss LSM880 Airyscan.
2. Discontinue offering "off-peak" rates, and increase rates on the Deltavision to \$30/hr, confocal rates to \$34/hr, and AxioObserver and Nikon Eclipse rates to \$10/hr. If these changes are implemented and instrument use remains steady, the IC account will remain above zero until December 2022 (Figure 7). These rates are still below the national average (see Appendix 5 for a thorough investigation of rates at other institutions).
3. Charge users for time scheduled on microscopes, rather than actual time used.
4. Consider dropping the service contract on the white light laser when the Leica's service contract is due again in December 2018.

Implementing some or all of these changes 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 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. 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.

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 2 state-of-the-art confocal microscopes (a 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. The Director of the IC continues to manage and train new users on this scope, and helped install a new ASI diSPIM Lightsheet microscope in April 2017. At least two additional microscopes (a JPK AFM and a 3-photon) will be housed in the space. Due to the increase in instrumentation, a new Director for the facility was hired in July 2017.

The Director of the IC, Amy Beaven, oversees the routine operation of the facility 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 737 researchers from at least 13 different departments in six colleges and three different campuses of the University of Maryland.

The IC is used by a diverse group of investigators, including undergraduates, graduate students, post-docs, technicians and faculty. Students enrolled in the annual 2-credit class CBMG688W/BSCI427, Principles of Microscopy, gain hands-on experience in the operation of the IC's brightfield, DeltaVision and Leica SP5X confocal microscopes. This course has trained an average of fifteen students each year for the past ten 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 FY10-17 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
- Advisory Committee: Dr. Charles Delwiche, Professor (CBMG) Dr. Jose Feijo, Professor (CBMG), Dr. Iqbal Hamza, Professor (ANSC), Dr. Wolfgang Losert, Professor (PHYS)

### **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 14 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 FY17

1. FY17: Throughout the year, the Director of the IC provided training and support for the PerkinElmer confocal spinning disk system in the Imaging Incubator, B0118 Physical Sciences Complex. This includes: training new users on the system, troubleshooting equipment problems, billing, and management of the KeyWatcher security system.
2. FY17: The Director served on the Imaging Incubator steering/hiring committee (with Arpita Upadhyaya, Lisa Taneyhill, and Patrick Kanold). The committee worked with ASI to properly configure and subsequently order an ASI diSPIM Lightsheet microscope (the Director wrote the sole source justification), and conducted a search to identify top candidates to oversee the Imaging Incubator. The new Director of the Incubator, Stephan Brenowitz, was hired in July 2017.
3. July 2016: The Director trained 4 employees of KeyGene to use the Zeiss LSM710 at the Shady Grove campus.
4. August 2017: The Director trained ~10 undergraduate students in the FIRE program to use the Zeiss AxioObserver fluorescence microscope.
5. September – December, 2016: The Director trained members of the class CBMG688W/BSCI427 (Principles of Microscopy) to use the Axiophot microscope, the DeltaVision deconvolution microscope, and the Leica SP5X confocal microscope.
6. October 18, 2016: The Director represented the Imaging Core at the UMB NeuroImaging mPower workshop.
7. December 2016: The Director assisted members of BSCI415 with the acquisition of confocal images.
8. February 13-17, 2017: The IC hosted/coordinated a Zeiss LSM 880 Airyscan demo.
9. March 6-10, 2017: The IC hosted/coordinated a JPK AFM demo for Biophysics and Bioengineering.
10. March 13-17, 2017: The IC hosted/coordinated a demo of the Leica SP8 confocal/digital Lightsheet microscope.
11. April 3-5, 2017: The Director negotiated with ASI, procurement, and Dr. Jose Feijo to receive and install the Imaging Incubator's ASI Lightsheet before the PO was issued, so that it could be available for the International Pollen Network Workshop. The Director set up the air table, and helped assemble and calibrate the instrument.
12. April 5-10, 2017: The IC hosted the international Pollen Network Workshop. The Director coordinated with Zeiss and Nikon to set up two demo systems in the IC (Zeiss LSM880 Airyscan and Nikon spinning disk). Workshop attendees, including seventeen students and various professors, instructors, and speakers, used these and existing systems in the IC (DeltaVision, Leica SP5X) and the Incubator (PerkinElmer, ASI diSPIM) to collect image data.
13. April 19, 2017: The IC hosted a Keyence BZ-X700 Microscope demo.
14. May 15, 2017: The Director wrote a sole source justification for the Imaging Incubator's JPK AFM system. The pending purchase was approved by the Board of Public Works on August 16.
15. April 27, 2017: The IC hosted a BioTek Lionheart microscope demo for Antony Jose's lab.
16. April – May 31, 2017: The Director coordinated with NIH-funded faculty in CBMG, Biology, ANSC, and Physics to prepare an NIH S10 Shared Instrumentation Grant for the purchase of a new Zeiss LSM880 Airyscan (proposal under review).
17. June 2017: The Director trained 10 undergraduate students in the FIRE program to use the Zeiss AxioObserver fluorescence microscope.

## Summary of Facility Usage

In FY17, the Zeiss LSM710 was used an average 16.6 hours/week and Leica SP5X was used 22.2 hours/week. The combined average usage of 39 hours/week is a 23% decrease from FY16. This can partially be attributed to a 62% drop in Leica SP5x use by Dr. Roy, who transferred most of his lab's imaging projects to his new spinning disk (installed in August 2016).

From FY09 to FY14, the Zeiss consistently saw more use than the Leica, but the trend reversed in FY15. Over the past 3 years, the Leica was used on average 370 more hours per year than the Zeiss. This is most likely because the Leica was upgraded with a new, more sensitive detector (HyD detector and time-gating technology) in FY14.

The Deltavision was used an average of 6 hours per week (virtually no change from FY16). The AxioObserver was used at the same rate, though this was a 61% increase over last year. The scope made it possible for new CBMG faculty member Dr. Scull to run preliminary experiments prior to the arrival of her laboratory's own microscope, and gave undergraduates in the FIRE program an opportunity to conduct their research projects. The newly acquired Nikon Eclipse (transferred to the IC in October 2016) has logged only 20 hours of use to date, but images acquired with its color camera have already been included in a publication (Du et al., 2017).

Table 1: Leica SP5X Summary Data:

Fiscal Year	Income	Total # Hours Used	Total 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
<b>Total</b>	<b>\$209,951</b>	<b>9,754</b>	<b>432</b>	<b>279</b>

Table 2: Zeiss LSM710 Summary Data:

Fiscal Year	Income from User Fees	Total # Hours Used	Total 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
<b>Total</b>	<b>\$225,631</b>	<b>9,081</b>	<b>44</b>	<b>212</b>

Table 3: DeltaVision Summary Data:

Fiscal Year	Income from User Fees	Total # Hours Used	Total 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
<b>Total</b>	<b>\$20,563</b>	<b>947</b>	<b>77</b>	<b>66</b>

Table 4: AxioObserver Fluorescence Microscope Data

Fiscal Year	Income from User Fees	Total # Hours Used	Total 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
<b>Total</b>	<b>\$4,055</b>	<b>694</b>	<b>0</b>	<b>28</b>

Table 5: Combined Microscope Data by Fiscal Year:

Fiscal Year	Income from User Fees	Total # Hours Used	Total 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
<b>Total</b>	<b>\$460,203</b>	<b>20,505</b>	<b>580</b>	<b>*585</b>

\*Including the old Zeiss LSM510, the total # training sessions increases to 737

During FY17, 41 different laboratories from 13 different departments (ANSC, BioENGR, Biology, CBMG, Chem/Biochem, Chemistry and Biomolecular Engineering, Earth Systems Science, Electrical and Computer Engineering, Environmental Science and Technology, Mechanical Engineering, Nutrition and Food Science, Physics) and 1 off-campus laboratory (USDA) made use of the facility's confocal microscopes. CBMG accounted for 51% of the total microscope use (Figure 3). Departments within CMNS accounted for 86% of use (Figure 4).

Figure 1: Top Microscope Users by Department FY17

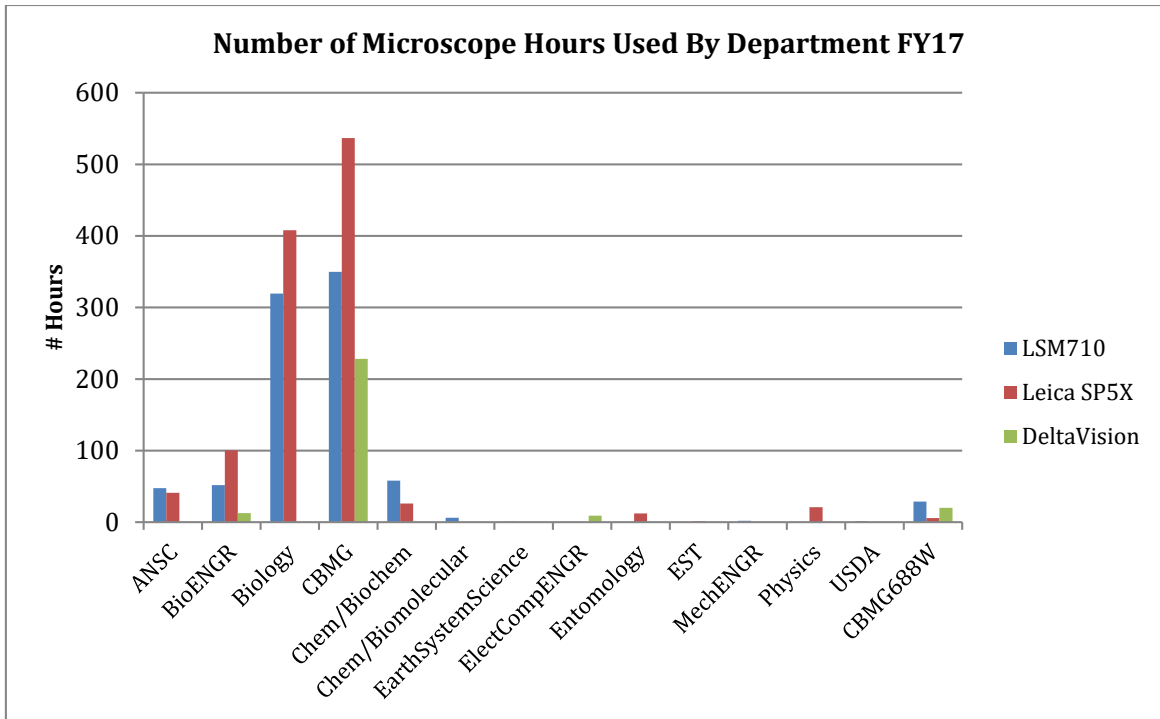


Figure 2: Top Microscope Users FY17

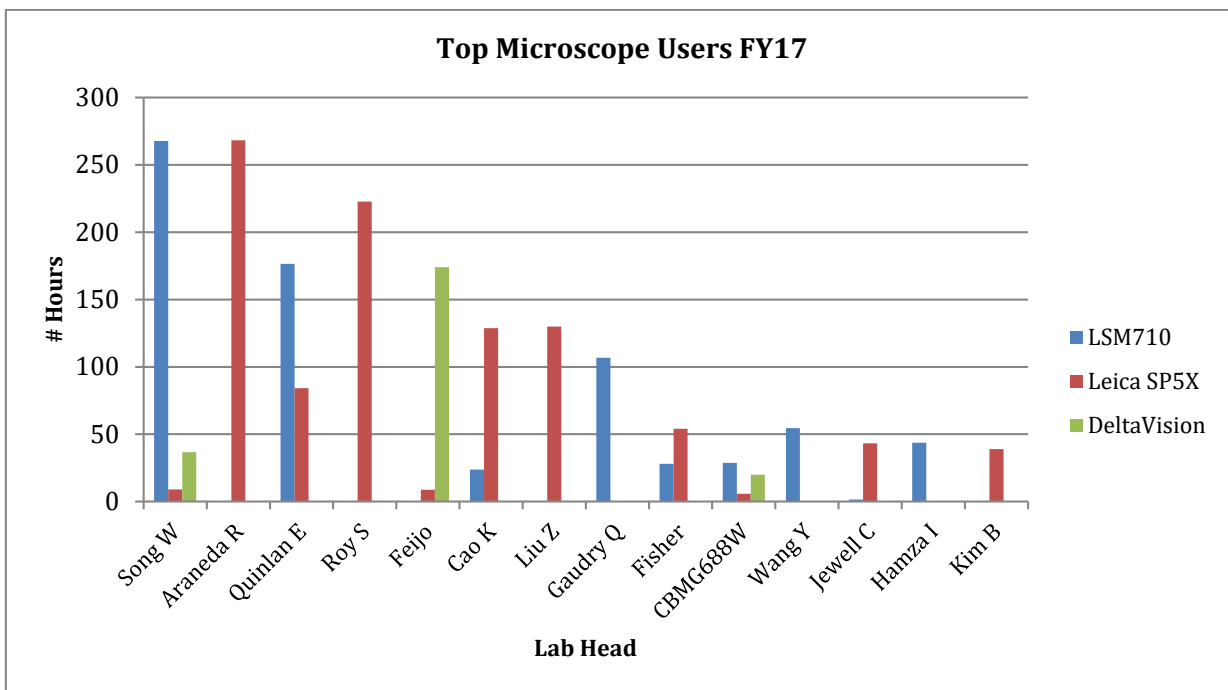




Figure 3: CBMG versus non-CBMG Use of Microscopes FY17

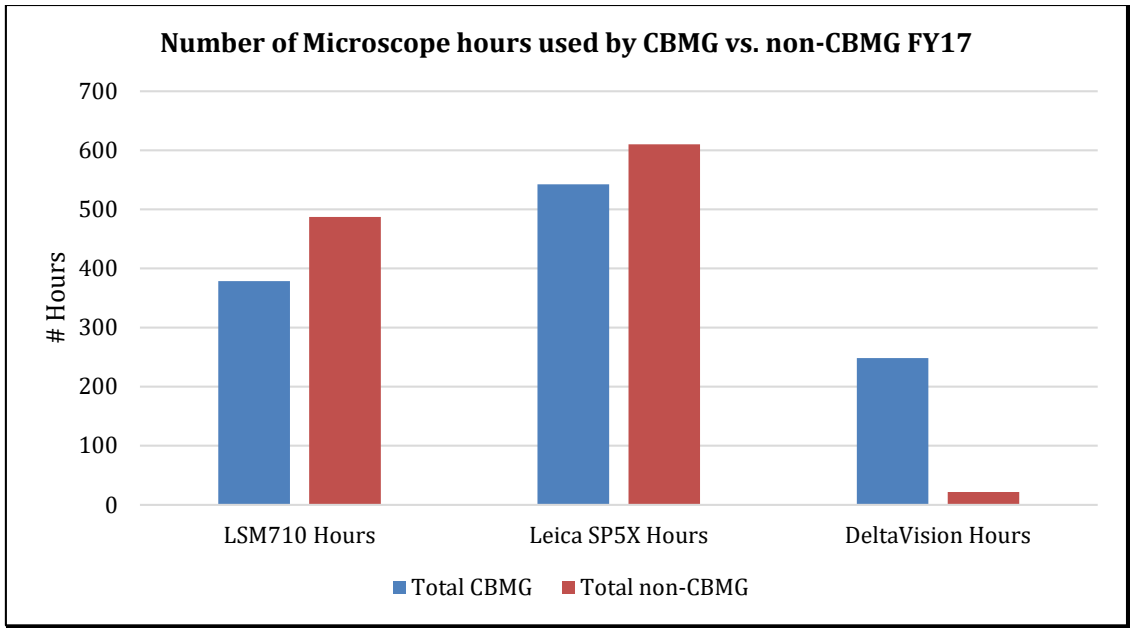
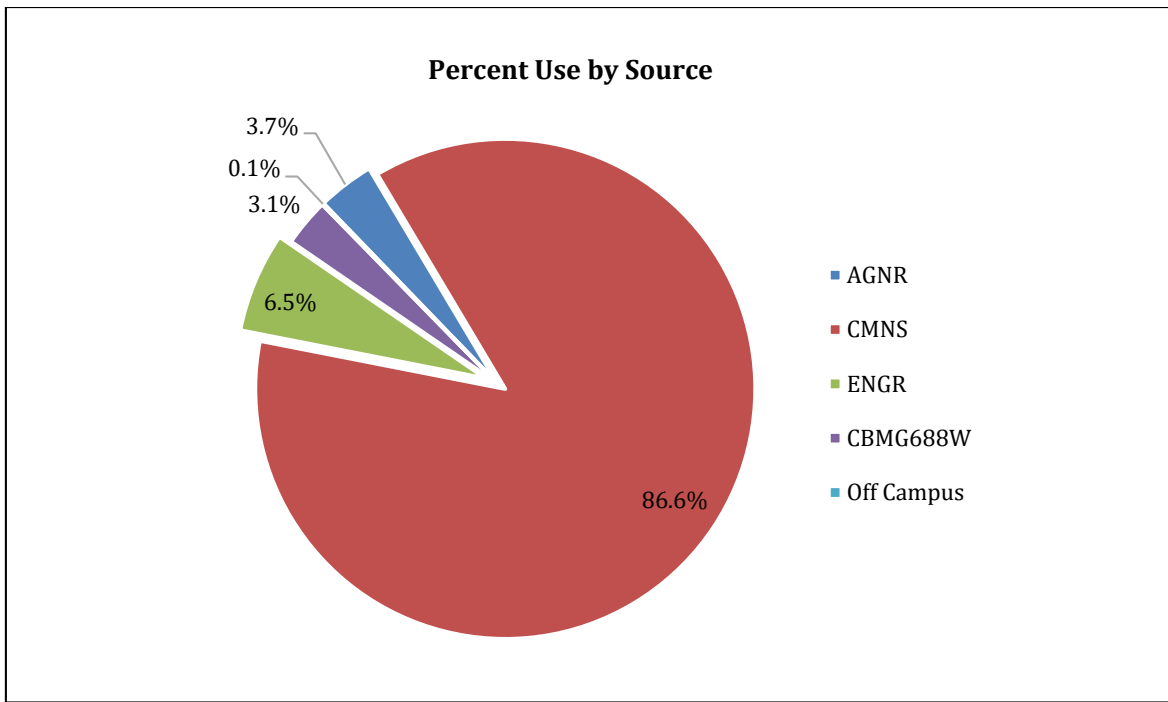


Figure 4: Percent Use by Source FY17



## Operating Cost Analysis

In the previous fiscal year, the IC netted \$3,484, but in FY17, consumable and service contract expenses for all facility microscopes exceeded the total income collected via charge-backs by \$8,783.52. At the end of FY17, the Imaging Core account held a balance of \$55,611.

Table 6: FY17 Income and Expenses

Instrument/ Source Income	Service contract cost	Consumable Cost	Total Expenses	Income	Income - Expenses
Zeiss LSM 710	\$19,969	\$785	\$20,754	\$26,055	\$5,301
Leica SP5 X	\$39,630	\$616	\$40,246	\$31,802	(\$8,444)
DeltaVision	\$17,461	\$160	\$17,621	\$7,267	(\$10,354)
Zeiss Observer	\$0	\$785	\$785	\$2,066	\$1,282
Axiophot	\$0	\$197	\$197	\$3.00	(\$194)
Nikon Eclipse	\$0	\$640	\$640	\$103	(\$537)
LSM710 IBBR	\$0	\$0	\$0	\$600	\$600
CBMG688W	\$0	\$0	\$0	\$1,700	\$1,700
Pollen Workshop	\$0	\$0	\$0	\$1,862	\$1,862
<b>Total</b>	\$77,060	\$3,181	\$80,242	\$71,458	(\$8,784)

Table 7: Total Imaging Core Facility Income and Expenses from FY09-FY17

Year	Total Income (including subsidies)	Total Imaging Core Expenses	Net Balance
FY2009	\$5,091	\$6,113	(\$1,023)
FY2010	\$68,233	\$29,564	\$38,669
FY2011	\$95,238	\$55,525	\$39,714
FY2012	\$87,278	\$76,562	\$10,716
FY2013	\$55,811	\$59,673	(\$3,862)
FY2014	\$57,184	\$59,876	(\$2,692)
FY2015	\$60,303	\$73,955	(\$10,802)
FY2016	\$79,028	\$75,544	\$3,484
FY2017	\$71,458	\$80,234	(\$8,784)
<b>Total</b>	<b>\$579,623</b>	<b>\$517,053</b>	<b>\$62,570*</b>

\* Actual account balance at end of FY17 was \$55,611

Table 8: Cost Breakdown: Leica SP5X

Year	Service Contract Cost	Expenses	Income	Income (subsidies)	Income - Expenses
FY2009	0	\$6,113	\$5,091	0	(\$1,023)
FY2010	\$26,000	\$2,376	\$18,363	\$37,500	\$27,487
FY2011	\$36,075	\$488	\$24,290	\$37,500	\$25,227
FY2012	\$52,296	\$2,056	\$21,882	\$37,500	\$5,032
FY2013	\$37,092	\$1,887	\$21,922	0	(\$17,057)
FY2014	\$37,092	\$360	\$25,160	0	(\$12,290)
FY2015	\$37,743	\$51	\$25,576	0	(\$12,218)
FY2016	\$37,743	\$609	\$35,865	0	(\$2,487)
FY2017	\$39,630	\$616	\$33,158	0	(\$7,088)
<b>Total</b>	<b>\$303,670</b>	<b>\$15,212</b>	<b>\$211,308</b>	<b>\$112,500</b>	<b>\$4,926</b>

Table 9: Cost Breakdown: LSM 710

Year	Service Contract Cost	Expenses	Income	Income (subsidies)	Income - Expenses
FY2009	0	0	0	0	0
FY2010	0	\$1,188	\$12,370	0	\$11,182
FY2011	\$17,730	\$1,232	\$33,448	0	\$14,487
FY2012	\$19,260	\$2,951	\$27,896	0	\$5,685
FY2013	\$19,260	\$1,434	\$33,889	0	\$13,195
FY2014	\$19,260	\$360	\$31,471	0	\$12,211
FY2015	\$19,755	\$51	\$27,655	0	\$7,848
FY2016	\$19,755	\$608	\$32,847	0	\$12,484
FY2017	\$19,969	\$785	\$27,080	0	\$6,326
<b>Total</b>	<b>\$134,989</b>	<b>\$8,608</b>	<b>\$226,655</b>	<b>0</b>	<b>\$83,418</b>

Table 10: Cost Breakdown: DeltaVision

Year	Service Contract Cost	Expenses	Income	Income (subsidies)	Income - Expenses
FY2014	\$0	\$739	\$371	0	(\$422)
FY2015	\$16,200	\$51	\$6,135	0	(\$10,097)
FY2016	\$16,200	\$323	\$6,824	0	(\$9,700)
FY2017	\$17,461	\$160	\$8,623	0	(\$8,998)
<b>Total</b>	<b>\$49,861</b>	<b>\$1,273</b>	<b>\$21,919</b>	<b>0</b>	<b>(\$29,216)</b>

**Projected Cost Analysis:**

If rates remain unchanged and microscope use stays at FY17 levels, the IC account balance will fall below zero in December 2020 (Figure 5). It should be noted that, between FY11-17, CBMG faculty members Cao, Jose, and Roy received \$26,659 in free microscope time as a part of start-up agreements with CBMG. In addition, Principles of Microscopy students received \$20,706 in free training and microscope time between FY10-17. Had the IC received this revenue (\$46,365 in total), the account wouldn't drop below zero until December 2022 (Figure 6).

Figure 5: Projected Account Balance

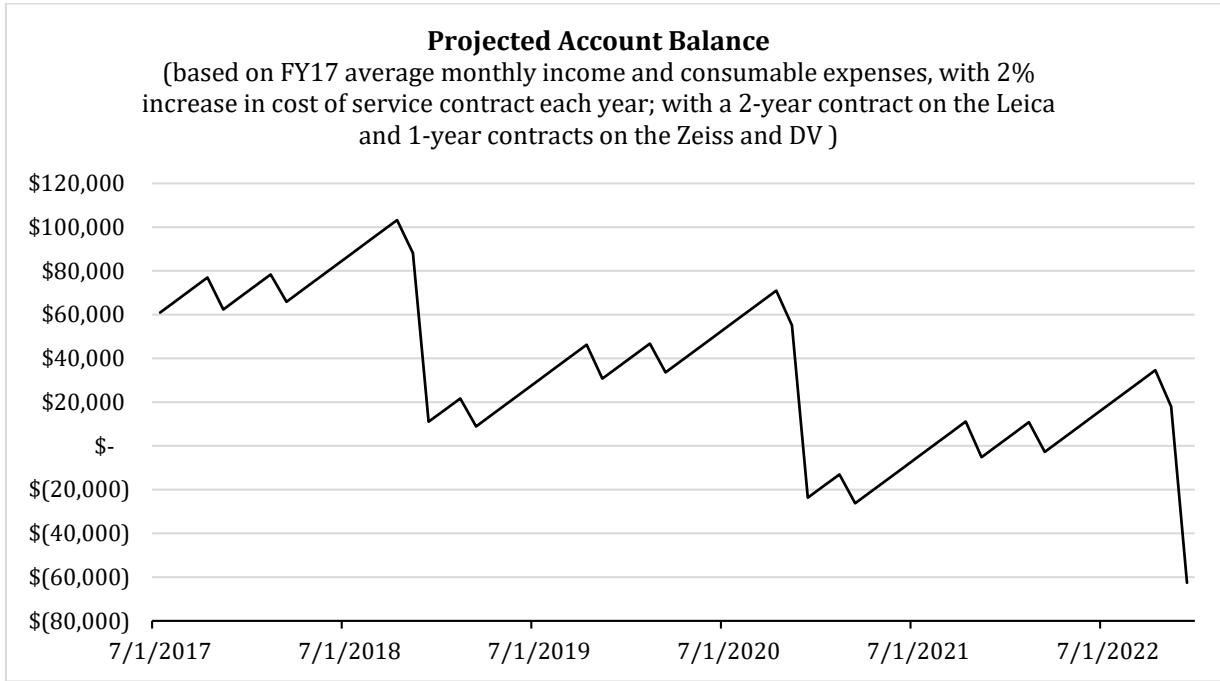
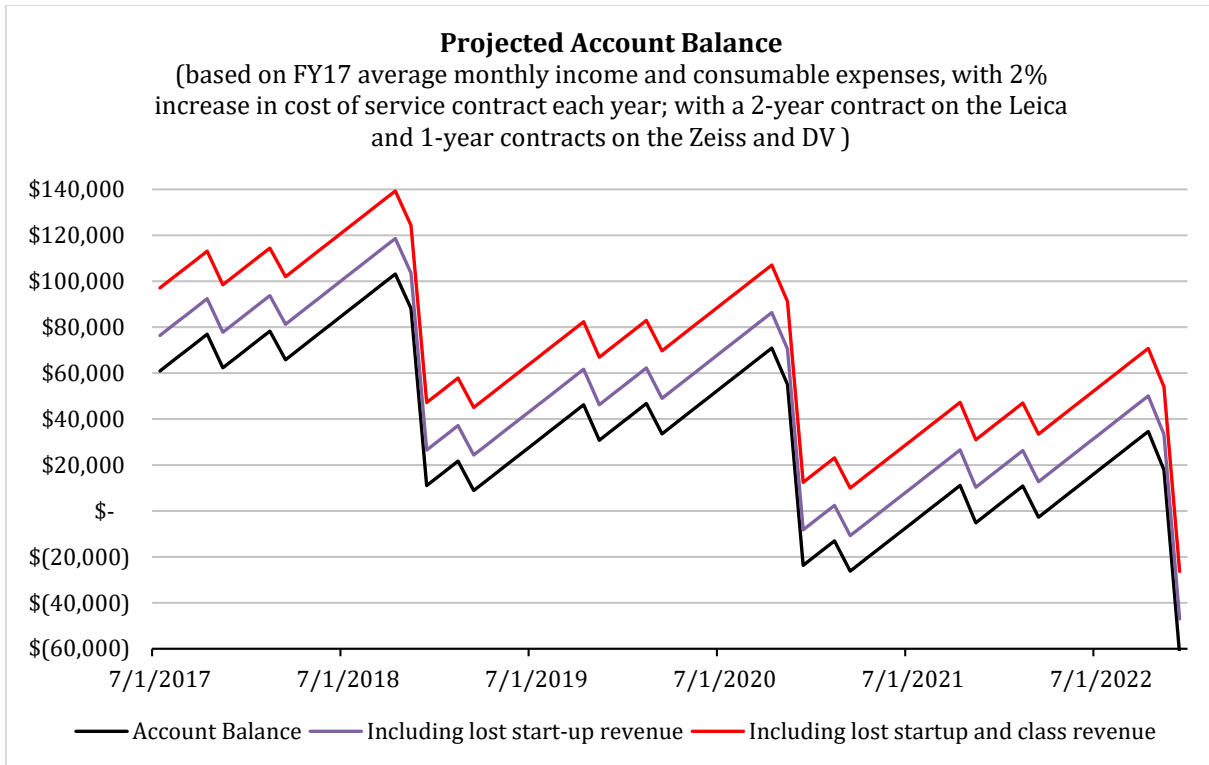


Figure 6: Projected Account Balance if the IC had received lost revenue:



**Proposed Rate Schedule:**

A thorough examination of confocal microscope rates at other institutions (Appendix 5) shows that the facility’s microscopes are still priced below average. The average rates (data updated August 2017) for similar microscopes at >30 institutions is as follows: \$36/hr for confocals, \$32/hr for DeltaVisions, and \$19/hr for widefield fluorescence microscopes.

The Director proposes the following rates system: discontinue the “off-peak” rates and increase confocal rates to \$34/hr, increase Deltavision rates to \$30/hr, and increase AxioObserver, Axiophot, and Nikon Eclipse rates to \$10/hr.

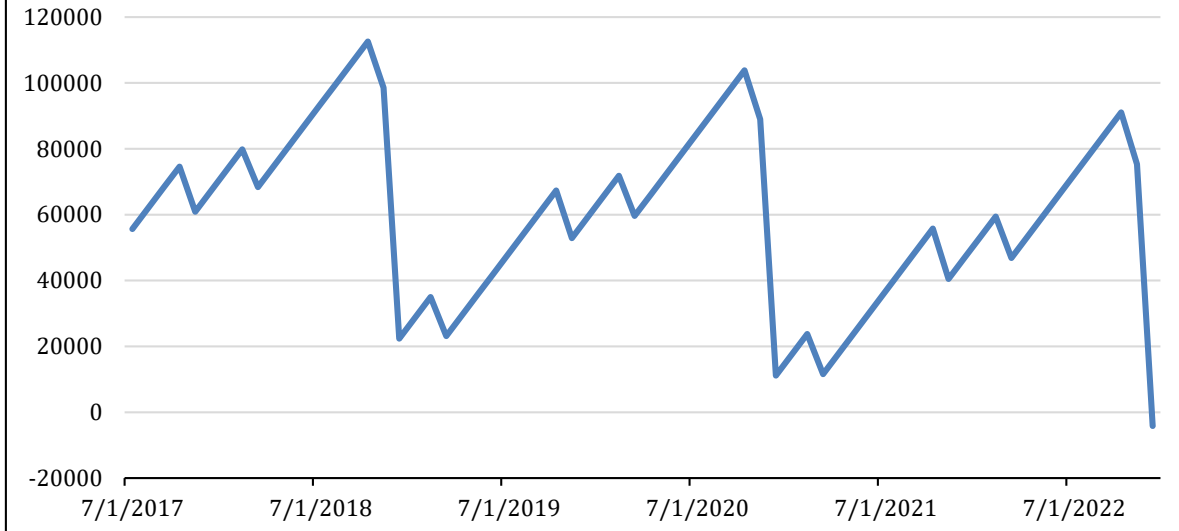
Table 11: Suggested Imaging Core Rates for Academic Year 2018

<b>Instrument</b>	<b>Users within CMNS, AGNR (excluding Vet Med), ENGR</b>	<b>UM users not affiliated with CMNS, AGNR, ENGR</b>	<b>Users not affiliated with campus</b>
Leica SP5X, Zeiss LSM710, PerkinElmer Spinning Disk, <b>Hourly Rate for Unassisted Use*</b>	\$34/hr	\$45/hr	\$85/hr
DeltaVision <b>Hourly Rate for Unassisted Use</b>	\$30/hr	\$45/hr	\$85/hr
Leica SP5X, Zeiss LSM710, DeltaVision, PerkinElmer Spinning Disk <b>14 hour overnight flat fee, 6pm-8am, M-F</b>	\$150	Inquire	Inquire
Leica SP5X, Zeiss LSM710, DeltaVision, PerkinElmer Spinning Disk <b>12 hour day rate (flat fee), 8am-8pm, M-F</b>	\$250	Inquire	Inquire
Leica SP5X, Zeiss LSM710, DeltaVision, PerkinElmer Spinning Disk <b>24 hour rate (flat fee), M-F</b>	\$350	Inquire	Inquire
Leica SP5X, Zeiss LSM710, DeltaVision, PerkinElmer Spinning Disk <b>24 hour rate (flat fee), Weekend Rate</b>	\$200	Inquire	Inquire
Leica SP5X, Zeiss LSM710, DeltaVision, PerkinElmer Spinning Disk <b>48 hour rate (flat fee), Weekend Rate</b>	\$400	Inquire	Inquire
Leica SP5 X, Zeiss LSM 710, DeltaVision, PerkinElmer Spinning Disk <b>Hourly Rate for Assisted Use</b>	\$50/hr	\$60/hr	\$180/hr
Leica SP5X, Zeiss LSM 710, DeltaVision, PE <b>Training Fee (per person)</b>	\$150	\$200	\$300
Zeiss AxioObserver, Axiophot and Nikon Eclipse <b>Hourly Rate for Unassisted Use</b>	\$10/hr	\$20/hr	\$40/hr
Zeiss AxioObserver, Axiophot and Nikon Eclipse <b>Training Fee (per person)</b>	\$25	\$40	\$100

\* Eliminate off-peak rates

Figure 7: Projected Account Balance Using New Rate System\*:

Projected Account Balance if Off-Peak Rates and Discontinued and Rates are Increased to \$30/hr for the Deltavision, and \$34/hr for the confocals



\* IC account will remain above zero until December 2022

**Appendix 1: Past Imaging Core Rates**

Equipment	Location	Purchase and/or Installation Date	In-College Rate History (Academic Year)
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
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
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; \$24.00/hr Off-Peak 2016/2017: \$28.00/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
Axiophot Fluorescence Microscope	Main lab	CoolSnap, Elements: July 2007 (purchased by CBMG)	\$2.00/hr since installation
Nikon Eclipse	0107B	October 2017 (relocated)	2016/2017: \$5/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

## 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.



- 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).
- 10/2017: A Nikon Eclipse transferred from Dr. Nicole Li's old lab on the 3<sup>rd</sup> floor of MICB to the IC, room 0107A MICB.

### Appendix 3: Imaging Equipment on Campus

Equipment	Purchase/ Installation Date	Owner (purchased by...)	Location	Available to anyone in CBMG?
Zeiss LSM 710 Confocal Microscope	10/2009	CBMG/CMNS	CBMG Imaging Core: 0107E MICB	Yes
Leica SP5X Confocal Microscope	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 Lightsheet	5/2017	CMNS (purchased with PSC building funds)	CMNS Imaging Incubator: B0118 PSC	Yes (not available for use yet)
Andor Spinning Disk	August 2016	Sougata Roy (CBMG)	Roy Lab, BRB	No
Zeiss LSM700 Confocal	~July 2012	IBBR/BioENGR	5131A PLS building	No
Zeiss LSM700 Confocal	Transferred in FY17	Margaret Scull (CBMG)	Scull lab, BRB	No
Zeiss LSM800 Airyscan Confocal	FY16	Lisa Taneyhill (ANSC)	Taneyhill lab, ANSC	No
Zeiss LSM710 Confocal	~FY14	Murphy/Peer (PLS)	Murphy/Peer lab, PLS	No
PerkinElmer Spinning Disk	FY08	Norma Andrews (CBMG)	Andrews lab, BRB	No

## Appendix 4: Publications

### Publications entailed the use of the Zeiss LSM 510:

1. Bish, S. E., W. Song, and D.C. Stein. 2008. Quantification of bacterial invasion into host cells using a beta-lactamase reporter strain: *Neisseria gonorrhoeae* invasion into cervical epithelial cells requires bacterial viability. *Microbes Infect.* 10:1182-1191.
2. Sikes, J. M. & Bely, A. E. Radical modification of the A-P axis and the evolution of asexual reproduction in *Convolutriloba* acoels. *Evolution and Development* 10, 619-631 (2008).
3. The MHC class II-associated invariant chain interacts with the neonatal Fc gamma receptor and modulates its trafficking to endosomal/lysosomal compartments. Ye L, Liu X, Rout SN, Li Z, Yan Y, Lu L, Kamala T, Nanda NK, Song W, Samal SK, Zhu X. *J Immunol.* 2008 Aug 15;181(4):2572-85
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5. Identification and characterization of an alternatively spliced variant of the MHC class I-related porcine neonatal Fc receptor for IgG.
6. Ye L, Tuo W, Liu X, Simister NE, Zhu X. *Dev Comp Immunol.* 2008;32(8):966-79. NF-kappaB signaling regulates functional expression of the MHC class I-related neonatal Fc receptor for IgG via intronic binding sequences. Liu X, Ye L, Christianson GJ, Yang JQ, Roopenian DC, Zhu X. *J Immunol.* 2007 Sep 1;179(5):2999-3011
7. Thyagarajan, R., N. Arunkumar, and W. Song. 2003. Polyvalent antigens stabilize BCR surface signaling microdomains. *J. Immunol.* 170: 6099-106.
8. Onabajo, O., M. Seeley, A. Kale, B. Qualmann, M. Kessels, S-H. Tan, and W. Song. 2008. Mammalian actin-binding protein 1 regulates BCR-mediated antigen processing and presentation in response to BCR activation. *J. Immunol.* 180(10):6685-95.
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10. Dong CH, Rivarola M, Resnick JS, Maggin BD and Chang C (2008) Subcellular co-localization of Arabidopsis RTE1 and ETR1 supports a regulatory role for RTE1 in ETR1 ethylene signaling. *Plant Journal* 53(2): 275-286
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14. Cheng, P. C., B. K. Brown, W. Song, and S. K. Pierce. 2001. Translocation of the B cell antigen receptor into lipid rafts reveals a novel step in signaling. *J. Immunol.* 166 (6):3693-701.
15. Song, W. 2001. Signaling, actin dynamics and endocytosis. *Acta Biophysica Sinica.* 17 (1):10-18.
16. Brown, B. K., and W. Song. 2001. The actin cytoskeleton is required for the trafficking of the B cell antigen receptor to the late endosomes. *Traffic.* 2 (6):414-27.
17. Parent, B. A., X. Wang, and W. Song. 2002. Stability of the B cell antigen receptor modulates its signaling and antigen-targeting functions. *Eur. J. Immunol.* 32:1839-46.
18. Li, C., K. Siemasko, M. R. Clark, and W. Song. 2002. Cooperative interaction of Igalpha and Igbeta of the BCR regulates the kinetics and specificity of antigen targeting. *Int. Immunol.* 14:1179-91.

19. Stoddart, A., M. L. Dykstra, B. K. Brown, W. Song, S. K. Pierce, and F. M. Brodsky. 2002. Lipid Rafts Unite Signaling Cascades with Clathrin to Regulate BCR Internalization. *Immunity* 17:451-62.
20. Thompson, M. V., and Wolniak, S. M. 2008. A Plasma Membrane-Anchored Fluorescent Protein Fusion Illuminates Sieve Element Plasma Membranes in Arabidopsis and Tobacco. *Plant Physiology*, 146: 1599-1610
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30. Berry D.L. and Baehrecke E.H. (2007) Growth arrest and autophagy are required for programmed salivary gland cell degradation in Drosophila. *Cell* 131, 1137-1148.
31. Martin D.N., Balgley B., Dutta S., Chen J., Cranford J., Kantartzis S., Rudnick P., DeVoe D.L., Lee C. and Baehrecke E.H. (2007) Proteomic analysis of steroid-triggered autophagic programmed cell death in Drosophila. *Cell Death and Differentiation* 14, 916-923.
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43. Chanroj, S. Lu Y, Padmanaban S. Nanatani K, Uozumi N, Rao R, Sze H. Plant-specific cation/H<sup>+</sup> exchanger 17 and its homologs are endomembrane K<sup>+</sup> transporters with roles in protein sorting. *J. Biol Chem.* 2011 Sep 30: 286(39):3393-41. Epub 2011 Jul 27.
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45. Campillo, E, Gaddam S., Mettle-Amuah D., Heneks J. 2012. A tale of two tissues: AtGH9C1 is an endo-B-1,4-glycanase involved in root hair and endosperm development in *Arabidopsis*. *PLOS One* 7(11):e49363.
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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.
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  12. 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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**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](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)
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**Publications that entailed the use of the Zeiss AxioObserver (to date):**

1. Bastarrachea LJ, Walsh M, Wrenn SP, Tikekar RV. 2017. Enhanced antimicrobial effect of ultrasound by the food colorant Erythrosin B. *Food Research International*. In press.

**Publications that entailed the use of the PerkinElmer spinning Disk (to date):**

1. Du, L., A. Zhou, A. Patel, M. Rao, K. Anderson, and S. Roy. (2017). Unique patterns of organization and migration of FGF-expressing cells during *Drosophila* morphogenesis. *Developmental biology*. doi: 10.1016/j.ydbio.2017.05.009

**Publications that entailed the use of the Nikon Eclipse (to date):**

1. Du, L., A. Zhou, A. Patel, M. Rao, K. Anderson, and S. Roy. (2017). Unique patterns of organization and migration of FGF-expressing cells during *Drosophila* morphogenesis. *Developmental biology*. doi: 10.1016/j.ydbio.2017.05.009

## Appendix 5: Example Confocal Rates at Other Institutions

Confocal Rates (updated August 2017)

Facility	Instrument	Hourly rate
Berkeley Biological Imaging Facility	Zeiss LSM 710	\$35
Berkeley Biological Imaging Facility	Zeiss LSM 510	\$29
Cornell University Life Sciences Imaging Core	Zeiss LSM 710	\$35
Cornell University Life Sciences Imaging Core	Leica SP2	\$20
University of Virginia School of Medicine	Zeiss LSM 510	\$34
University of Virginia School of Medicine	Zeiss LSM 510	\$38
University of Virginia School of Medicine	Zeiss LSM 510	\$54
Northwestern University Biological Imaging	Leica SP5	\$38
Northwestern University Biological Imaging	Zeiss LSM 510	\$37
Arizona State Imaging Facility	Leica SP5	\$40
Duke University Light Microscopy Core	Leica SP5	\$26.50
Duke University Light Microscopy Core	Zeiss LSM 780	\$26.50
Ohio State University	Olympus FV 1000	\$30
Michigan State U Center Advanced Microscopy	Zeiss LSM 510	\$35
Michigan State U Center Advanced Microscopy	Olympus FV 1000	\$35
University of Washington Keck Facility	Zeiss LSM 510	\$42
University of Washington Keck Facility	Leica SP2	\$42
Oklahoma State University	Leica SP2	\$30
UNC Chapel Hill Michael Hooker Facility	Leica SP2	\$39
University of Connecticut	Leica SP8	\$15
UVA Keck Center	Zeiss LSM 510	\$35
UVA Keck Center	Leica SP5X	\$35
Oregon State University	Zeiss LSM 780	\$21
Oregon State University	Zeiss LSM 780	\$18
Yale School of Medicine	Zeiss LSM 510	\$45
Yale School of Medicine	Leica SP5	\$45
Texas A&M	Olympus FV 1000	\$41
University of Maryland School of Medicine	Zeiss LSM 510	\$40
Colorado State University	Zeiss LSM 510	\$40
Boise State University	Zeiss LSM 510	\$43.12
Rockefeller University	Leica SP5	\$49
Notre Dame	Nikon A1	\$26
Washington University in St. Louis	Nikon A1	\$32
Washington University in St. Louis	Leica SP2	\$32
Florida International University	Leica SP2	\$19.65
Penn State College of Medicine	Leica SP eight	\$35
Perlman School of Medicine	Zeiss LSM 710	\$85
Perlman School of Medicine	Leica STED	\$85
University of California, Davis	Olympus FV 1000	\$35
UC Santa Cruz	Leica SP5	\$25
Indiana University	Leica SP5	\$17.75
U of Arizona, Env Health Sciences	Leica SP2	\$32
Oregon Health and Science University	Zeiss LSM 780	\$39.60
Oregon Health and Science University	Olympus FV 1000	\$33.00
U of Georgia Biomedical Microscopy Core	Zeiss LSM 710	\$35
University of Illinois at Chicago	Zeiss LSM 510	\$35
University of Illinois at Chicago	Zeiss LSM 710	\$41
UC San Diego	Olympus FV 1000	\$36
UC San Diego	Zeiss LSM 510	\$36
Baylor College of Medicine	Nikon A1	\$28
University of Michigan Medical School	Zeiss LSM 510	\$43
University of Michigan Medical School	Leica SP5X	\$30
<b>Average</b>		<b>\$36</b>

DeltaVision Rates (updated August 2017)

<b>Facility</b>	<b>Instrument</b>	<b>Hourly rate</b>
Berkeley Biological Imaging Facility	DeltaVision	\$28
Northwestern University Biological Imaging	DeltaVision	\$35
Duke University Light Microscopy Core	DeltaVision Elite	\$13.80
University of Washington Keck Facility	DeltaVision	\$84
Rockefeller University	DeltaVision	\$37
Notre Dame	DeltaVision	\$18
Washington University in St. Louis	DeltaVision	\$32
Florida International University	DeltaVision	\$8.49
Penn State College of Medicine	DeltaVision	\$20
Perlman School of Medicine	DeltaVision	\$75
University of California, Davis	DeltaVision	\$35
Indiana University	DeltaVision	\$17.75
U of Arizona, Env Health Sciences	DeltaVision	\$25
Oregon Health and Science University	DeltaVision	\$27.50
U of Georgia Biomedical Microscopy Core	DeltaVision	\$30
University of Arizona Microscopy Alliance	DeltaVision	\$35
University of Arizona Microscopy Alliance	DeltaVision	\$25
University of Illinois at Chicago	DeltaVision	\$25
UC San Diego	DeltaVision	\$28
Baylor College of Medicine	DeltaVision	\$28
University of Michigan Medical School	DeltaVision	\$43
<b>Average</b>		<b>\$32</b>

Spinning Disk Rates (updated August 2017)

<b>Facility</b>	<b>Instrument</b>	<b>Hourly rate</b>
Cornell University Life Sciences Imaging Core	Andor Spinning Disk	\$30
Northwestern University Biological Imaging	Leica Spinning Disk	\$37
Duke University Light Microscopy Core	Andor Spinning Disk	\$18.00
University of Connecticut	Andor Spinning Disk	\$15
Rockefeller University	PE Spinning Disk	\$37
Notre Dame	Andor Spinning Disk	\$16
Perlman School of Medicine	Olympus Spinning Disk	\$80
UC San Diego	Perkin Elmer Spinning Disk	\$36
<b>Average</b>		<b>\$34</b>

Widefield Fluorescence Microscope Rates (updated August 2017)

<b>Facility</b>	<b>Instrument</b>	<b>Hourly rate</b>
Cornell University Life Sciences Imaging Core	Olympus Widefield	\$15
University of Washington Keck Facility	Widefield	\$26
UVA Keck Center	Widefield	\$15
<b>Average</b>		<b>\$19</b>