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1 **Global Survey of Microscopy Core Facilities**

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34 **KEY WORDS:** Microscopy Survey, Core Microscopy Facility, Longitudinal Study, User Fees,
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36

37 **ABSTRACT**

38 As part of two open international core facility surveys focused on microscopy and flow
39 cytometry, we obtained an in-depth snapshot of their state-of-play. Here we focus on
40 microscopy cores across “The Americas”, “Asia Pacific” and “Europe & Africa” with responses
41 from 241 facilities. We compared instrument types and numbers, staffing, user fees, funding,
42 etc. This revealed both remarkable similarities and notable differences. For example, the
43 staff/instrument ratio in Europe & Africa was smaller compared to other regions World View
44 and Asia Pacific had a larger proportion of electron microscopes. Importantly, we want to
45 emphasize that the anonymized raw data is made available for anyone to do their own further
46 mining and analysis, including cross-correlations and constrained groupings. This survey will
47 serve as an essential baseline for future longitudinal studies following trends across all metrics
48 as our facilities evolve.

49

50 **INTRODUCTION**

51

52 Many core facilities (sometimes referred to as shared resource laboratories) generally operate
53 with limited knowledge of how they compare with others of similar size, similar institutes,
54 and/or geographical region. Over the years, many of these facilities have benefited from *ad*
55 *hoc* or structured surveys specific to their core competencies. For example, the Association of
56 Biomolecular Resource Facilities (ABRF) has several valuable broader surveys including job
57 satisfaction, compensation, and benchmarking¹⁻⁴ or a Federal Ministry of Education and

58 Research (BRBF, Germany) funded study of research quality in core facilities ⁵, as well as many
59 other independent surveys⁶⁻⁹. By developing the framework for a longitudinal study we hope
60 to standardize the questions and make comparisons over time possible. We also hope that
61 other groups running future surveys will follow suit noting some of our discussions around
62 potential future improvements. Ultimately, our colleagues serving as coordinators, managers
63 and directors must periodically report progress and justify value/need to administrative and
64 scientific oversight committees. Furthermore, cores are not, or should not, be static and ideally
65 evolve to support their institutions' research programs, scientific need and as technological
66 advancements occur. With this in mind, we developed a matched survey for both microscopy
67 and flow cytometry¹⁰ communities to obtain a snapshot of core facilities of these closely related
68 and most commonly found single or combined core facilities. We surveyed common
69 operational and usage metrics, including supporting personnel resources (staff and
70 instruments) and will repeat this survey periodically over time with predominantly the same
71 questions and adjusted for trends and the needs of the community and allow longitudinal
72 changes to be identified. This survey will allow core facilities to benchmark against their global
73 or regional peers and provide important information in these comparisons to support
74 conversations with national funders, local institutional management/oversight committees and
75 commercial manufacturers. (We asked a comprehensive set of questions to make the data
76 useful to as many groups as possible, and to help future proof subsequent surveys to follow
77 trends that may become important.)

78

Commented [1]: Copied from the Flow survey.

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79 The microscopy survey captured data between September 2020 and February 2021, publicized
80 via various networks, including the Confocal and Microscopy Listserv's, Bioimaging UK,
81 European Light Microscopy Initiative, Light Microscopy Australia, Bioimaging North America,
82 and various social media accounts that helped cascade awareness, attracting responses from
83 241 different core facilities. Although the geographic spread was wide, some countries were
84 represented by only one facility. To determine if there were any geographical differences in the
85 responses, we have grouped the data into three global regions: The Americas (North and South
86 America), Europe and Africa, and Asia Pacific (Asia and Australia). Unfortunately representation
87 from lower income regions was naturally fewer making it hard to draw any local conclusions,
88 but these have been grouped to ensure that everyone's data has contributed. We note that the
89 anonymized raw data has been made available for deeper analysis. Further granularity for
90 reporting here would lead to too few data points to be significant and risk specific facilities
91 being individually identifiable.

92 The anonymized raw data is available in spreadsheet form to allow further correlations
93 that were not addressed in this report, which has focused on broad global trends
94 (**Supplementary Table 1**). This is the first dataset of the planned series to allow for temporal
95 evaluation of changes that take place in microscopy and flow cytometry core facilities
96 operations and instrumentation over time. From a historical perspective, this survey also
97 included questions about the response and impact of COVID-19.

98

99 **RESULTS**

100 **Demographics**

101 This survey captured responses from 241 participants from Microscopy core facilities with good
102 representation of the three geographical regions: The Americas (105, 43.57%), Europe and
103 Africa (79, 32.78%), and the Asia Pacific (57, 23.65%) (**Fig. 1**). The “World View” is the combined
104 data from all regions and we also include a global country-based distribution heat map to allow
105 readers to inspect the composition of each region (**Supplementary Fig. 1**). There was also a
106 good spread of user facility focus, and while Life Science/Biomedical was the dominant primary
107 area of interest (Question 2, “How would you categorize the primary area of research of most
108 of your users?”) (71 % World View, **Fig. 2A**), this was largely because the group was the
109 easiest to reach via larger microscopy and cytometry societies. However, it was noted that
110 many core facilities supported research across scientific disciplines with 18 % having Material
111 Science users, which was notable greater in the Asia Pacific (30%). When it came to the
112 number of users (Question 8, “How many total users do you have?”) supported annually in core
113 facilities, the World View maximum frequency was 51-100 users with 23% of cores including
114 both Europe & Africa (28%) and Asia Pacific (23%), while the maximum frequency for The
115 Americas was 101-200 users at 24% (**Fig. 2B**). To understand the ability of core managers to
116 work on their own research rather than strictly service responsibilities (Question 9, “As a
117 manager/director/head of the Microscopy Facility, do you work on your own research?”), 57%
118 of lab heads responded affirmatively in the World View, with The Americas (63%), followed by
119 Europe & Africa (56%) and Asia Pacific (53%) which was nearly evenly split (**Fig. 2C**). We asked
120 the question “What is the annual operating cost of your Microscopy Facility?” (**Supplementary**
121 **Fig. 2**, Question 10) and noted a bimodal distribution with the World View peaking at \$101K-
122 \$200K/annum and >\$1M, both with just a little more than 20% of respondents. However, only

123 62% included staff salary in their calculation (**Supplementary Fig. 2**, Question 11, “Does the
124 total operating cost from the above question include staff salary?”) and thus, underestimates
125 the aggregate true cost of many core facilities and may also indicate that some institutions
126 subsidize all or part of their Microscopy Facility staff salaries.

127

128 **Number and Types of Instruments**

129 As expected, most core facilities had multiple microscopes, with a large majority having
130 between 3 to 20 instruments and the highest frequency being Europe & Africa at 11-20
131 systems, World View and The Americas at 6-10 systems, and Asia Pacific at 3-5 systems/core
132 (**Fig. 3A**, Question 4, “How many major microscopes do you have in your Core Facility?”). Wide-
133 field and confocal microscopy were the most common instrument types in each core facility,
134 followed by Super-Resolution Microscopy (SRM), and Electron Microscopy (EM), with other
135 instrument types being much less common. Interestingly, a closer inspection of Question 5,
136 “How many of each type of instrument?” (**Supplementary Table 1**), we determined that over 50% of all
137 respondents (122/241) had at least one SEM, TEM or Cryo EM and 45% of all facilities having at least
138 one LM also had at least one SEM, TEM or Cryo EM. This somewhat surprising high level of mixed
139 platform composition of so many facilities, may in part reflect increasing consolidation across many
140 institutions.

141 The World View trend was very similar with regards to the ratio of instruments to staff (**Fig. 4**),
142 with the exception of the Asia Pacific which proportionally had more electron microscopes at
143 increased staffing levels (3+ staff). It was notable that the ratio of wide-field, confocal, and
144 SRMs in The Americas and Europe & Africa for up to 3-4 staff was similar and as the number of

145 staff increased to 5 and greater, these labs trended to be more diverse in their offerings, with
146 an increase in EM, and decrease in wide-field microscopy (Fig. 4). From a World View
147 perspective, there were approximately 2 confocal microscopes and SRMs combined to every
148 wide-field microscope, suggesting that core facilities mostly focus on high-end instrumentation,
149 while lower cost instrumentation are probably owned by individual research labs rather than
150 cores (Fig. 3C). It will be very interesting to see how the more niche or newer technologies
151 trend over the coming surveys and whether platforms like cryo-EM, volume-EM, SRM and light
152 sheet microscopy start to become more common across facilities or remain restricted to
153 specialist and regional core facilities.

154

155 **Staffing**

156 **Number of Staff versus Instruments and Users**

157 As expected, the staffing numbers increased relative to the number of instruments within the
158 core facility (Fig. 5, Question 6, “How many Staff members do you have (excluding you)?”
159 versus Question 5, “How many of each type of instrument?”). For this analysis we added one
160 staff member to include the facility manager. Unfortunately, the specific number of how many
161 staff members are needed per number of instruments was difficult to extract as the range was
162 very broad and more likely reflected the instrument complexity and the funding models that
163 support individual core facilities, rather than the total number of instruments within the facility.
164 As a general trend, as calculated from the slope, The Americas had 3.4 instruments/staff
165 member, Asia Pacific 1.8 instruments/staff member, while Europe & Africa respondents had the

166 most instruments/staff member at 4.1, with a global average of 3.1 instruments/staff member
167 (**Supplementary Fig. 3**). These ratios are remarkably similar to that found in the Schmidt¹¹. It
168 must be noted, however, that there were a few labs that had a far greater number of total
169 instruments compared to staff members (**Fig. 5**) and vice versa (e.g. a lab with 2 instruments
170 was being supported by 30 staff) that impacted the metrics. Also, since the survey did not
171 accurately capture the number of Full Time Equivalents (FTE) (likely as we did not define this
172 term for regions less familiar with its use) the total number of staff could be a result of more
173 part-time workers in the labs being reported as FTE and thus more staff per instrument. It could
174 also be that more Europe & Africa labs also host cytometers or other non-microscopy
175 instruments that were not captured within this survey, and thus additional staff would be a
176 result of other non-measured equipment and/or services. Additionally, it could also reflect that
177 the core labs in different regions offer full-service support versus models that emphasize users
178 trained to work independently. The complexity of the instruments also dictated the number of
179 support staff. For example, the ratio of SRM verses confocal microscopes tended to stay
180 constant in the Americas, where the staff number was greater, while in Europe and Africa, the
181 proportion of confocal microscopes was greater relative to the number of SRMs. Thus, the
182 instrument/staff ratio does not necessarily increase in a predictable way simply by knowing the
183 total number of instruments as reflected in the slope (**Supplementary Fig. 3**) and discussed
184 above. Nevertheless, taken together, these instrument/staff member ratios still can serve as a
185 very useful guide for all cores, and especially in the event that some core facilities deviate
186 substantially from the World View of about 3 instruments/staff member, or ~2
187 instruments/staff member in an EM concentrated facility. Parsing the number of FTE versus the

188 number of users (**Fig. 6**), there was little FTE change in facilities having 0-
189 200 users (~2-3FTE) but the number of FTE increased with facilities having at least 300 users
190 (~5FTE) to facilities with 1000+ users (~10 FTE) in the World View. Interestingly, the World
191 View number of systems versus revenue was largely flat (3-5 system) up \$500K USD and cores
192 with \$500K+ USD in revenue had an average of 6-10 systems (**Fig. 7**). Overall, this data likely
193 reflects the sheer diversity in types of cores, microscope composition, institutional cost
194 recovery expectations and their user base size, to name a few.

195 **Annual Operating Costs versus Number of Instruments or Staff**

196 When considering all respondents, the global annual operating costs of each core (all
197 currencies converted to US Dollars) were spread fairly evenly throughout the survey range
198 (**Supplementary Fig. 2**, Question 10), with a peak at \$101- 200K USD and little difference
199 between the regions with regards to the spread of operating costs per lab. It was notable
200 that the Asia Pacific had the majority of lowest cost and highest cost facilities when looked at
201 collectively (**Fig. 8**). However, in Question 11 (**Supplementary Fig. 2**), we asked if the operating
202 costs reported in Question 10 included salary, since many cores do not account for this in their
203 budget models. In general, we assumed that most labs with lower annual running costs
204 did not include salaries, whereas the higher end almost exclusively included staff costs. Thus,
205 to get a better sense of true operating costs for those who reported all costs, we separated and
206 plotted the surveys that did include salaries (**Fig. 8A**) versus those that did not (**Fig. 8B**). For yes
207 respondents, operating costs for The Americas and Europe & Africa had ~ 20% in each bin from
208 \$101K - 1M USD with their peaks being \$101-200K USD and \$201-300K USD, respectively.
209 China, notably trended upwards across the operating cost range with a peak of over 30% of

210 respondents with greater than \$1 million USD, probably reflecting the higher proportion of EM.
211 In The Americas, and Europe & Africa, income sources were split fairly evenly between fee-for-
212 service (being slightly greater) and institutional support, with grants direct to core facilities
213 being the least common source of income (**Fig. 9**). In contrast, the Asia Pacific showed a much
214 higher proportion of direct institutional support and it will be interesting to see if these trends
215 in funding sources will hold true in future surveys.

216 Overall, the funding sources were remarkably similar (World View 36.2% Fee for Service,
217 Institutional Support 34.5%, 21.2% Grants, 8.1% Other) (**Supplementary Fig. 2**, Question 13,
218 “What percentage do you receive from the following sources of funds?”), but a closer look
219 showed these funding sources (**Fig. 9**) had notable regional differences. Specifically, when the
220 number of staff within a core facility was considered, in The Americas and Asia Pacific, fee-for-
221 service increased in proportion with increased staff numbers, whereas Europe & Africa showed
222 the opposite trend with an increase in the proportion of direct grants to the core facilities with
223 7+ staff. For Europe & Africa and The Americas, this switch to institutional support in core
224 facilities with higher staffing numbers could reflect larger national centers (e.g. EMBL, NIH,
225 MRC) that are funded directly by charities or national/international funders, and our survey did
226 not differentiate these facilities from those that are set-up within academic institutions or
227 commercial labs.

228

229 **Instrumentation**

230 In 2019, a large majority of core facilities were seeing utilization increase with a significant
231 proportion having over 25% (**Supplementary Fig. 4 A**, Question 43, “How did your utilization

232 change in the last 3 years up until the end of 2019?). This is encouraging and could reflect that
233 the popularity, value, and/or size of core facilities were still growing pre-COVID. Probably one
234 of the most important aspects of Microscopy Facility management is setting a fee structure
235 which needs to balance the budget requirements of cost recovery, local/regional competition,
236 funding agency regulatory stipulations, and most importantly affordable enough to attract
237 users and for the science to get done³. To support this task, we asked what was the hourly fee
238 for unsupervised (**Supplementary Fig. 2**, Question 21, “What is your average hourly fee for
239 Unsupervised /Regular session?”), supervised (**Supplementary Fig. 2, Q22**, “What is your
240 average hourly fee for Supervised /Assisted session?”) and training sessions (**Supplementary**
241 **Fig. 2**, Question 24, “What is your average hourly fee for Training sessions?”). For example, The
242 World View fee for Wide Field Microscopes for “unsupervised”, “supervised” and “training” was
243 \$10-30. In an earlier 2014 international microscopy survey⁹, the instrument hourly rates trend
244 was similar across the collective regions, however, within the regions themselves differences
245 were also identified. In our current survey, we focused on the worldwide regions
246
247 We asked the question about average weekly usage and number of active users
248 (**Supplementary Fig. 2**, Question 16, “What is the average weekly usage and total number of
249 users per instrument in your facility?”) and percentage utilization (**Supplementary Fig. 2**,
250 Question 18, “What percent of equipment is utilized by Internal academic users, External
251 academic users, Commercial users, and Other”). This section is probably the most complex one
252 to analyze as so many facilities have somewhat different business models, but it provides

253 important comparative information on the user base composition and tool capacity/utilization
254 per type of instrument that could help serve as a useful baseline.

255 We also queried respondents about how old instruments were handled (**Supplementary Fig. 2,**
256 Question 33, “How are old instruments handled?”), service contracts (**Supplementary Fig. 2,**
257 Question 34, “What is the source of funding for service contracts?”, Question 35, “Who services
258 your Instruments?”, Question 36, “What percent of your high end equipment do you maintain
259 on a service contract?”) and other service and technical related issues (**Supplementary Fig. 2,**
260 Questions 35-42). Overall, this section should be very useful to core managers to understand
261 how peer institutions handle this significant operating cost which also relates to up-time.
262 Furthermore, it provides instrument manufacturer specific data and supplies a snapshot of how
263 their instruments were performing. Interestingly, and strikingly, the greatest frequency of
264 facilities that maintained high end equipment under contract (Question 36) at 76-100% with
265 World View at 35% with Europe & Africa nearly 50% and Asia Pacific ~22%. It was also notable
266 that the Asia Pacific peak frequency was <25% maintained under contract at 35% of facilities.
267 This finding, in light of differences in funding sources (Question 13), is very interesting, but it
268 also could reflect utilization levels, instrument complexity, purchase structures (extended
269 warranties), local equipment/service reliability and/or sales/service/support model between
270 the regions, to name just a few.

271

272 **COVID-19**

273 Considering we are now well beyond the primary impacts of COVID-19 on core facilities, we still
274 felt it worthwhile to memorialize and reflect on the collective experiences of our respondents

275 (see **Supplementary Fig. 2**, Questions 44-53 and **Supplementary Fig. 4 A-D**). Some of the
276 questions that we asked were what was the impact on utilization (e.g., Question 44
277 **Supplementary Fig. 4 B** “During lockdown, how did COVID-19 impact the utilization of your
278 facility?”) and personal protective equipment (PPE) requirements (Question 50, “What PPE are
279 required to use your core?” **Supplementary Fig. 4 D**) the sterilization (e.g., Question 53 “Who
280 sterilizes the equipment during COVID-19?”) and For example, the response to Question 44
281 (**Supplementary Fig. 4 B**) showed an impactful World View average of >40% decrease in
282 utilization with The Americas and Europe & Africa having at least a 50% decrease while the Asia
283 Pacific reported an ~20% decrease. Interestingly, and perhaps unsurprisingly, one of the biggest
284 technological levers during COVID-19 (and beyond) was the use of some form of online training
285 with nearly 60% of facilities (World View) planning to incorporate. Indeed, a knock-on effect,
286 while not captured by our study, we anecdotally observed microscope related companies and
287 core managers themselves seemed to be more accepting and rapidly adopting remote
288 demonstrations to support purchase decisions. We feel this remote training/demonstration is
289 now having a positive impact on the efficiency, environmental impact and sustainability of
290 cores. Additionally, despite being in the rearview mirror, these COVID-19 responses are an
291 invaluable resource and our learnings may be applied for yet unknown challenges, disasters or
292 other contingencies in the future and, of course, what would be done differently.

293

294 **Applications/Methods being used within Core Facilities**

295 To understand what type and relative levels of imaging approaches were being used, the survey
296 looked at the different applications being leveraged in their facility (**Fig. 10 A**, Question 27,

297 “What advanced Microscopy applications are you currently using?”). This showed that The
298 America’s were generally doing more complex (e.g. FCS, FRAP, FRET, TIRFM) and newer
299 applications (e.g. Clearing, Expansion, multiplexing microscopy) compared to the other regions.
300 Europe & Africa also demonstrated a greater number of fluorescence techniques over the Asia
301 Pacific which reported greater EM applications. The difference with Asia Pacific compared to
302 the other regions could partly reflect that the respondent labs were more heavily involved with
303 EM compared to Light Microscopy (LM) techniques and that the survey may not have reached
304 as many LM labs, whereas the survey may not have reached as many EM labs in the non-Asia
305 Pacific regions. A similar relationship was also observed for data analysis, with The Americas’
306 core facilities being more involved with the data analysis compared to Europe and Africa
307 followed by Asia Pacific (**Fig. 10 B**, Question 28, “What Visualization and Data Analysis
308 approaches do you use?”). Interestingly, at the time, World View use of Machine Learning was
309 over 25% of respondents while Asia Pacific had ~15% of respondents. One explanation of the
310 regional variation in data analysis, which can be labor-intensive, may reflect differences in what
311 is typically offered as a service or technology access in the respective regions. Meaning, data
312 analysis may be outsourced to different institutional resources or left to the user to tackle
313 independently.

314

315 **DISCUSSION AND CONCLUSION:**

316 Our analysis focused on the regional commonalities and differences, which is complementary to
317 the Schmidt survey¹¹ that was focused more on the general international trends. As this survey
318 shows there were many points of commonality and, of course, some differences between the

319 regions. As our long-term goal is to develop a longitudinal study of microscopy cores, we
320 wanted to benchmark where possible, a few prior published surveys with handful of questions
321 and accordant answers that were substantially same.

322 As with the accompanying flow cytometry survey, we realized that several questions could have
323 been better worded, for example, when asking for the number FTE in the core, as with the flow
324 survey, we should have more clearly defined FTE and included the respondent. Phrasing will
325 also be improved in the next survey to remove ambiguity in some questions and also give
326 example. Thus, we would modify Question 6 “How many Staff members do you have? (excluding
327 you)” to read “How many Staff members do you have (including you)” to make analysis much easier.
328 Additionally, Question 7 “How many Full Time Equivalent (FTE) staff do you have? (excluding you eg.
329 3.25 FTE),” might be better worded as “How much total dedicated staff time supports your facility? (e.g.,
330 if you are an academic lead with 20% effort dedicated to the facility, this equals 0.2; if you have a part-
331 time employee working 3 days a week, this equals 0.6, and if you work full-time/5 days a week, this
332 equals 1.0, if you have all of these of these three, add them together).” In retrospect, these clarifications
333 would minimize ambiguity on such important questions. One missed opportunity is asking whether
334 the core facility included more than one type of platform, e.g. does your core also host flow
335 cytometry, or another modality? It will also include new areas that develop, such as does your
336 core have dedicated image analysis staff. We will also run a trial pilot survey across multiple
337 different facilities from different geographical regions to identify any potential problems in
338 advance and ease of analysis. It may be more time consuming upfront, but will save a
339 significant effort later on.

340

341 There are many excellent core facility resources and surveys to be sure^{5,8,9,12-16}, but relatively
342 few that were focused specifically on Microscopy, fewer that cover multiple imaging forms (e.g.
343 light, electron, x-ray, atomic force) and even fewer that were worldwide. For this comparison,
344 we relied on an initial survey taken in 2011⁹ which encapsulated data from 175 respondents
345 which effectively reflects a 10-year gap in survey completion. We also compared where possible
346 a 2020 survey in the UK¹ that included 46 light microscopy facilities and was chronologically
347 close to our 2021 survey reported herein. While the 2011 prior survey lacked the same
348 geographical breadth and distribution (63% North America, 29% Europe and 8% Asia Pacific),
349 we still felt it worthwhile to draw some comparisons with key overlapping questions and other
350 surveys were also included and compared. Interestingly, the Asia Pacific respondents in both
351 surveys (Wallrabe⁹ and here) had a greater proportion of SEM and TEM systems (2011, 50% and
352 57.1%, 2021, 58% and 67%, respectively) compared to the World View (2011, 29.7% and 34.3%,
353 46% and 50%, respectively). Notably, all regions showed cores with an increase in the number
354 of EM systems between these surveys. While not possible here, if the same labs could have
355 been tracked in a longitudinal study, it would have been inciteful to know if this reflected a shift
356 in core composition/focus or simply an increase in inclusion of EM lab respondents. Labs with
357 both EM and Light Microscopy World View were 34.3% in 2011 and 28.9% in 2021 with only 1
358 EM ab of 26 did not report having some form of LM. Unsurprisingly, a much larger proportion of
359 respondents had widefield and confocal microscopes in both surveys (e.g., confocal World
360 View, 90% in 2011, 75% in 2021). Although curiously, there was a relative drop in confocal
361 microscopes in our more recent survey which may correspond to the increase in EM cores as
362 discussed above. To get a more granular perspective, we looked closely at the top advanced

363 microscopy applications in these studies. FRAP, FRET, TIRF, Clearing Microscopy, Single
364 Molecule, FLIM and Structured Illumination topped the list (rank ordered greatest to least) and
365 ranged from 52-25% of respondents in 2021. In 2011, FRAP, FRET, Photo Activation, FLIM and
366 Super Resolution (rank ordered greatest to least) and ranged from 67-45% of respondents.
367 While there were some minor differences in advanced choices between the surveys (Clearing
368 Microscopy added in 2021, Photo Activation removed in 2021 and Super Resolution in 2011
369 was split to Single Molecule and Structured Illumination) overall, there was remarkable
370 similarity of the dominant techniques. Notably, EM tomography was the most popular EM
371 Technique in 2011, while in 2021, Focused Ion Beam-SEM, Energy Dispersive Spectroscopy and
372 Cryo Electron Tomography (rank ordered greatest to least) but ranged from 10-20%
373
374 Funding sources also had a very interesting trend, where almost all regions (except Canada) in
375 2011 derived about one-third of their operational funds from user fees, compared to 2021
376 where ~50% in The America's, 45% in Europe & Africa and the Asia Pacific remained the same
377 at about 33%. Did this reflect an increase in expectations/pressure for cost recovery over the
378 last decade, or simply more organized or updated cores with increased usage/user-base that
379 resulted in increased revenues? In comparison, for the UK light microscopy survey¹,
380 institutional support (43.3%) constituted a little larger portion of funding sources compared to
381 user fees (39%). The user fees were not appreciably different than the 45% for Europe & Africa.
382
383 This survey serves as a baseline for the longitudinal studies to compare and contrast the global
384 microscopy cores and to see what new technologies become mainstream, how funding

385 mechanisms and costs change and how staff levels change over the coming years, to name a
386 few. It was good to see Schmidt¹¹ have very similar findings in a completely independent
387 survey. Any future surveys hopefully will be combined and also informed from results here as
388 well as adapting to changes in technology and core business models. For example, we found
389 that there were questions that should have been asked and that will help inform us of the way
390 future surveys will be worded. We certainly found that some questions may have been
391 ambiguous, which became apparent when the data was analyzed. For example, Question 6,
392 “How many Staff members do you have (excluding you)?” we believe some respondents did not
393 take into account if they had one or more part-time employees, which could inflate our
394 calculations and correlations of the number of staff relative to other metrics. Our intent for
395 Question 7, “How many Full Time Equivalent (FTE) staff do you have (excluding you e.g. 3.25
396 FTE)?” was to accommodate part-time staff, but looking at inconsistencies in responses for both
397 questions, suggested that the term “FTE” may not be familiar or commonly used in some
398 geographic regions. Additionally, Question 10, “What is the annual operating cost of your
399 Microscopy Facility?” and Question 11, “Does the total operating cost from the above question
400 include staff salary?” while provided useful reporting ranges, left sufficient vagueness when
401 correlating with overall facility usage and equipment type and number. Specifically, we believe
402 many core facilities, particularly smaller ones, have budgeting models that often exclude some
403 or all salary, overhead, depreciation and/or core managers do not have detailed budget
404 planning that include all costs that many larger cores have.

405

406 What was striking overall was how similar most responses were between the regions. Where
407 notable differences were observed, this could in part reflect the respondents within those
408 regions, especially within the Asia Pacific region that resulted in proportionally more materials
409 and electron microscopy core facilities. But even in such cases, the results were remarkably
410 similar in most aspects surveyed. Of course, we found that there were questions that should
411 have been asked and this will help inform us how to improve wording in the next survey.
412 Furthermore, since we concomitantly surveyed, with substantially identical questions, our
413 closely aligned flow cytometry facility colleagues (and often incorporated as part of microscopy
414 cores) we refer you to the companion article within this issue¹⁰ for direct comparisons of these
415 2 surveys. Finally, since the survey was so data rich, it was not possible to compare and contrast
416 every possibility within the scope of this manuscript. For this reason, we have made all the
417 survey data responses anonymized (only country identifier provided) and available as a
418 spreadsheet accessible to the public (**Supplementary Table 1**). This will allow for the
419 microscopy community opportunities for further analysis and data to be mined for specific
420 questions that may be useful for other purposes.

421 Finally, for those interested in suggestions for a trimmed version of questions for your own
422 future survey that still would allow many important comparisons with those included herein,
423 we color-coded the question list (**Supplementary Fig. 2** – slides 2-4) with “Black” being high
424 priority, “Orange” being medium priority and “Red” being low priority. Driving our lower
425 prioritization rating were a series of Covid questions, questions that had very high uniform
426 and/or obvious responses (e.g., Question 23, “Do you offer training for users?”), or questions

427 that we considered important but required much more time effort for the respondents (e.g.,
428 Question 21, “What is your average hourly fee for Unsupervised/Regular session?”).

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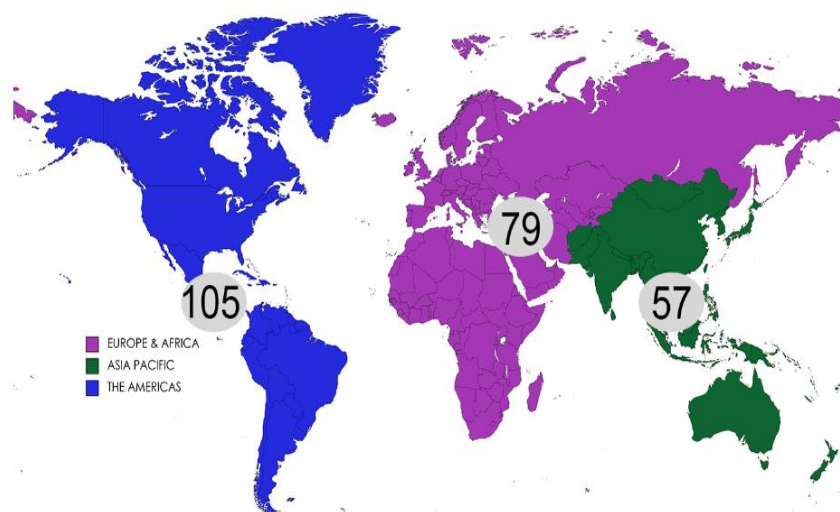
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FIGURES



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476 **Figure 1.** Microscopy Survey Demographics. This global survey included 241 participants from
477 Microscopy core facilities from three geographical regions: The Americas at 43.57% (blue),
478 Europe and Africa* at 32.78% (magenta), and the Asia Pacific at 23.65% (green). *Note, Europe
479 and Africa region (magenta) includes Russia (0 participants) and the Middle East (4
480 participants).

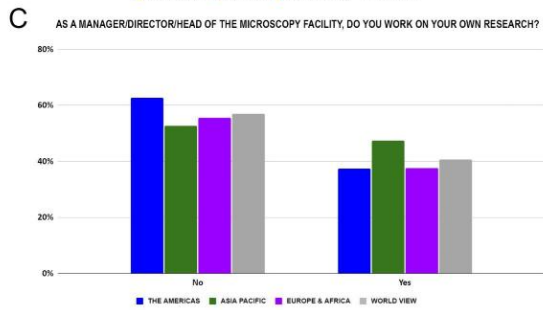
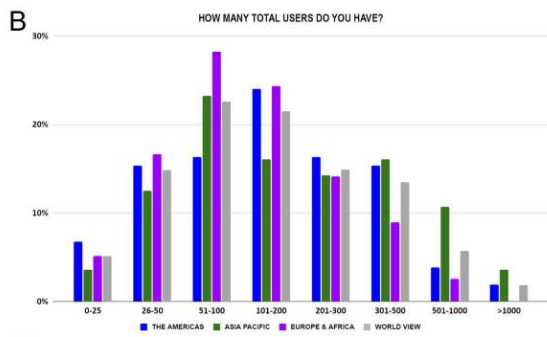
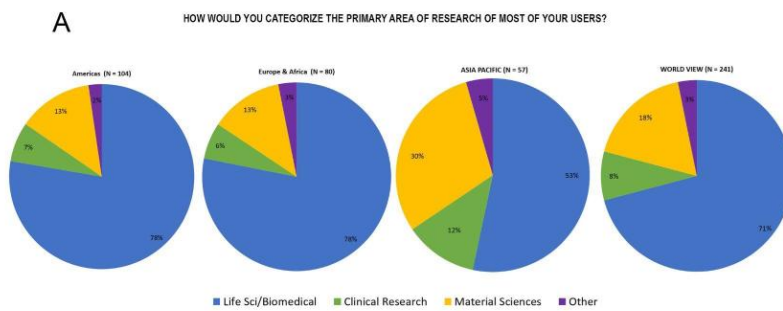
481 See Supplementary Figure 1 to see global core microscopy facility distribution heatmap (by
482 country).

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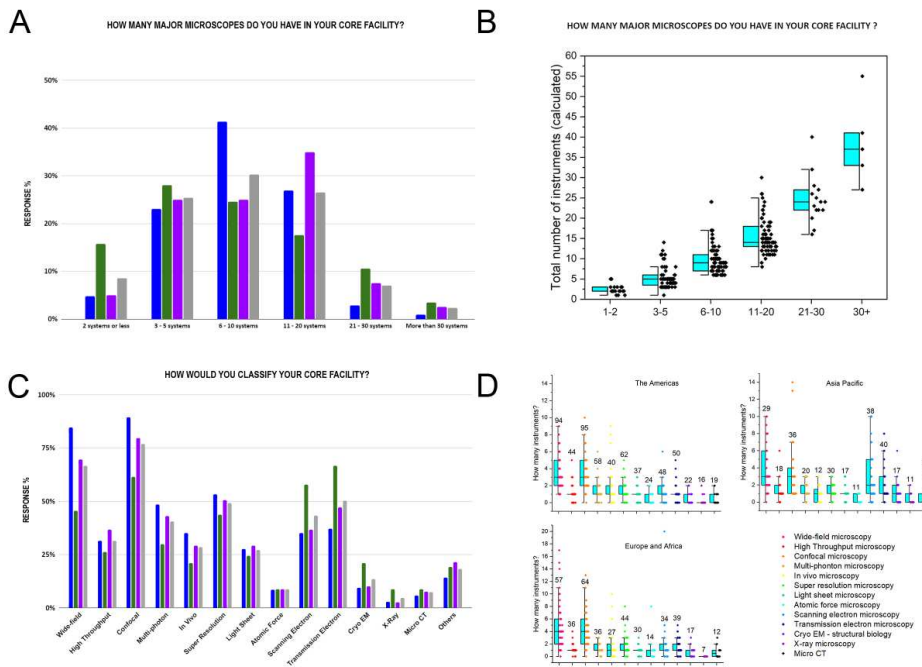
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Figure 2. Scientific Emphasis, User size and remit across regions (A) Pie Charts of the primary area of research for users, (B) Bar graph of distribution of total users (C) Bar graph of Manager/Director ability to do own research.



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Figure 3. Major Microscope Metrics. (A) Bar graph of major microscope number. (B) Scatter plot of how many major microscopes. (C) Bar graph of microscope types. (D) Regional scatter plot showed distribution of major microscopes.

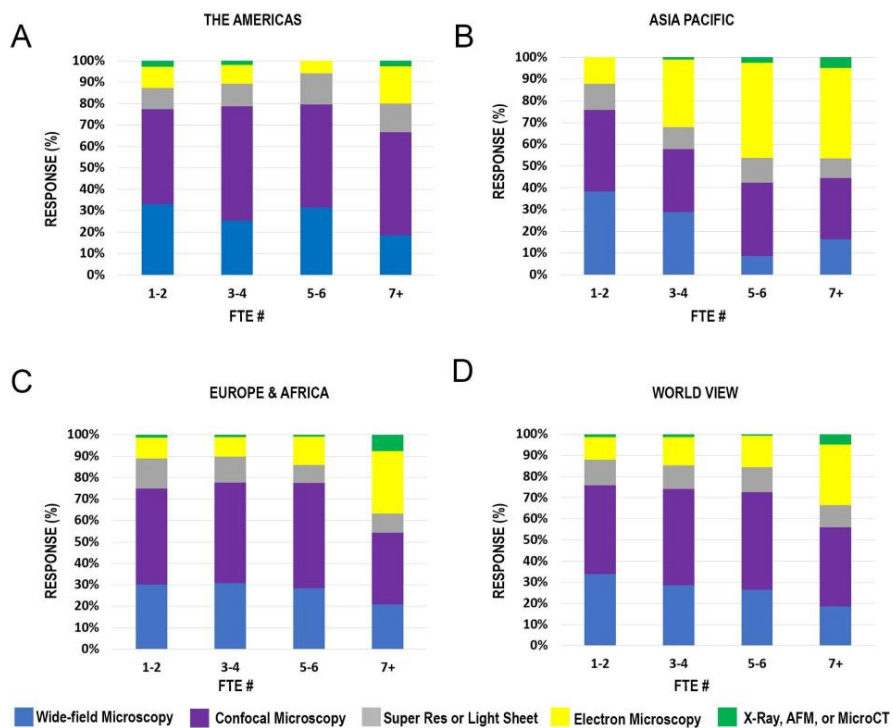
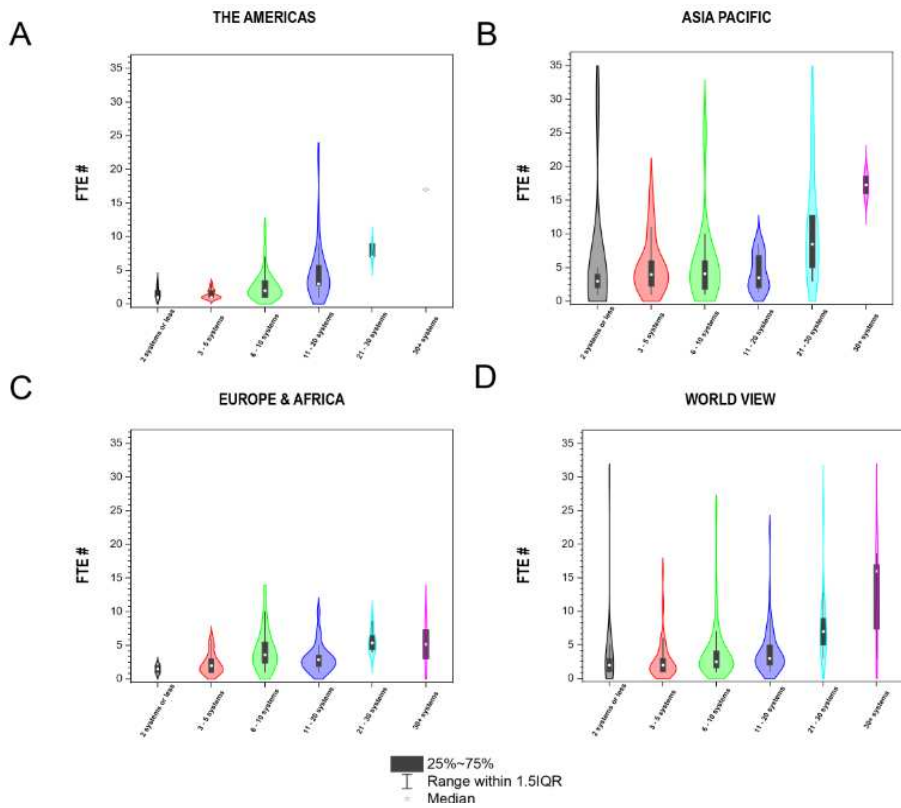


Figure 4. Instrument Type versus Full Time Equivalent (FTE). (A) Bar chart of The Americas. (B) Bar chart of Asia Pacific. (C) Bar chart of Europe & Africa. (D) Bar Chart of World View.

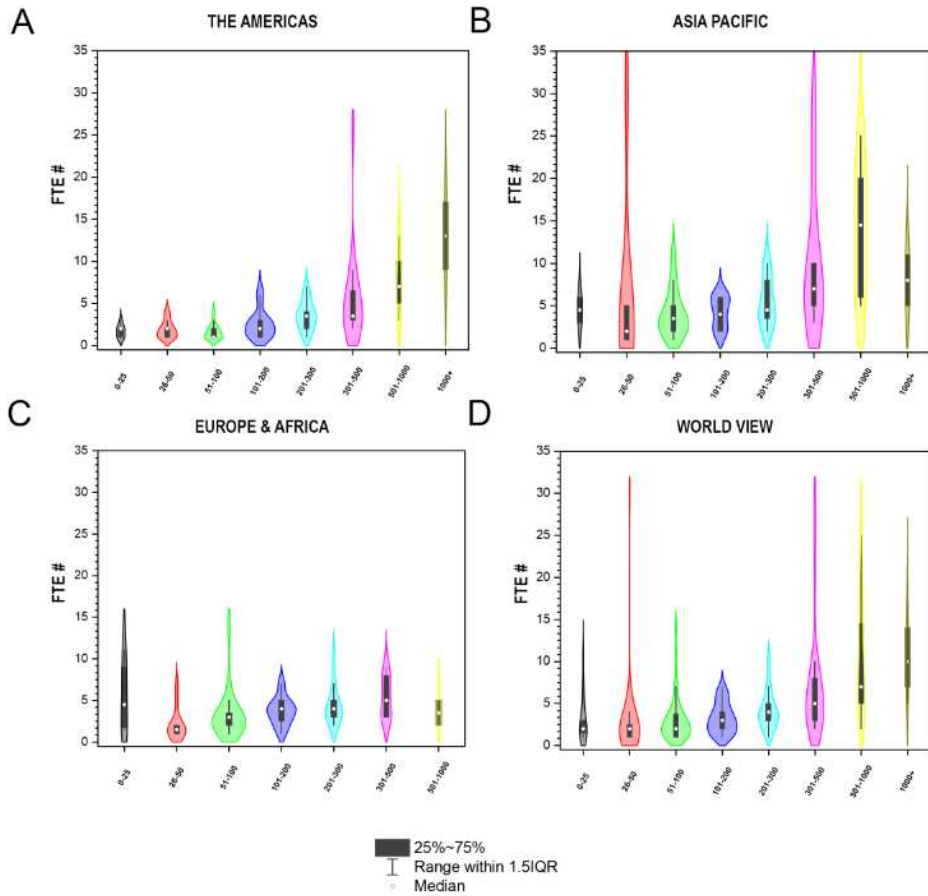
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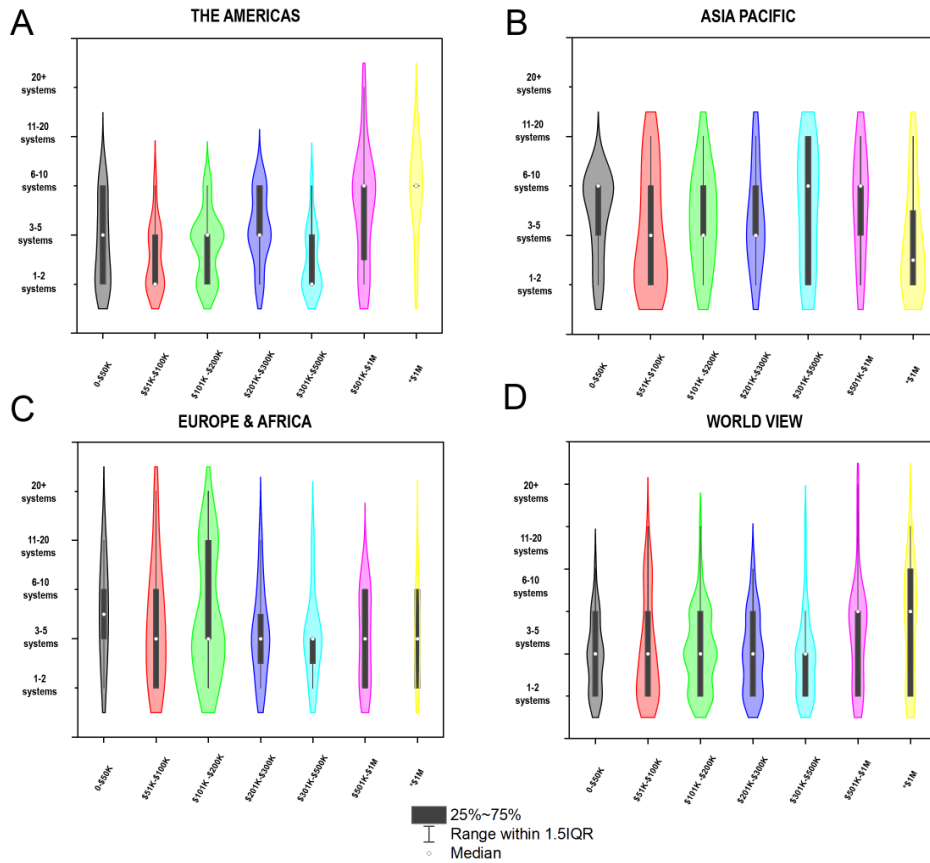
528 **Figure 5.** Full-Time Equivalent (FTE) Versus System Number Metrics across the Regions. (A) The
529 Americas (B) Asia Pacific. (C) Europe & Africa. (D) World View.
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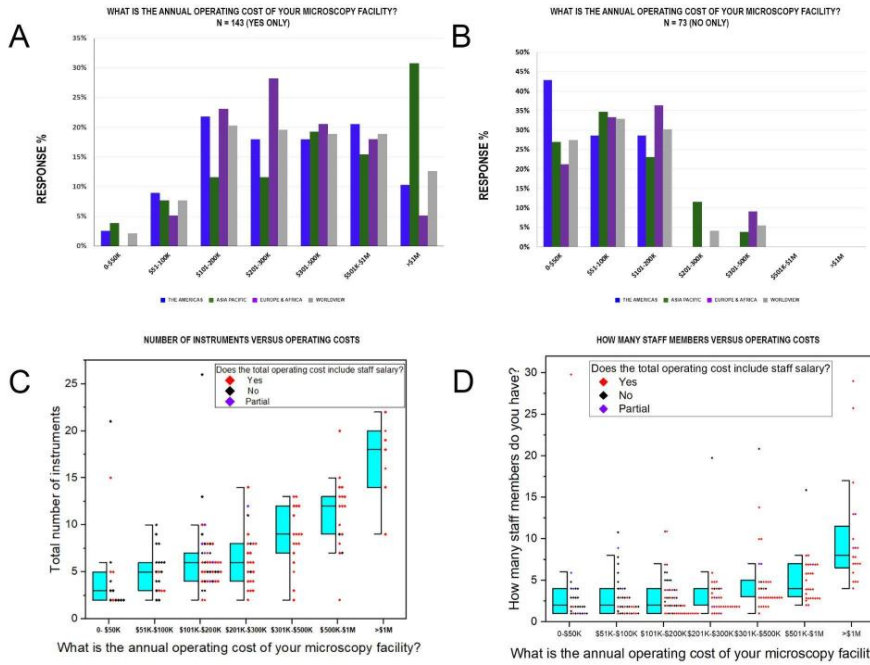
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 537 **Figure 6.** Full-Time Equivalent (FTE) Versus User Number Metrics across the Regions. (A) The
 538 Americas (B) Asia Pacific. (C) Europe & Africa. (D) World View.

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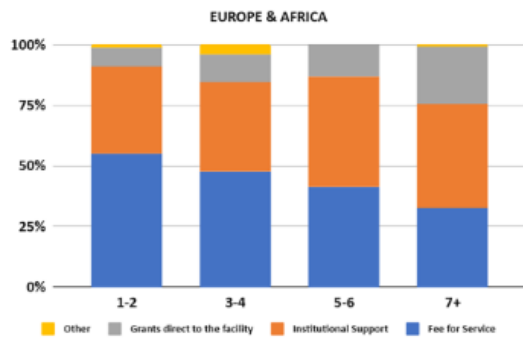
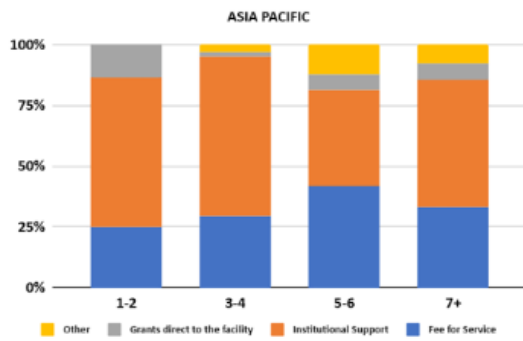
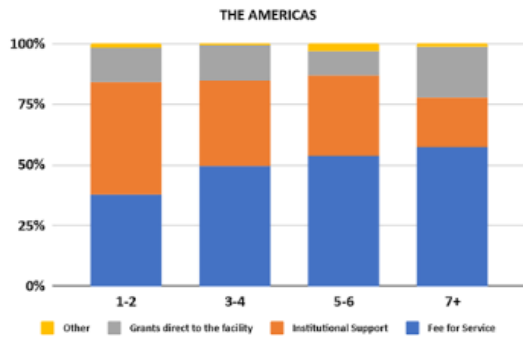


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 551 **Figure 7.** System Number Versus Revenue Metrics across the Regions. (A) The Americas (B) Asia
 552 Pacific. (C) Europe & Africa. (D) World View.

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 566 **Figure 8.** Annual Operating Costs Metrics (A) Operating costs across regions (B) Did operating
 567 costs including staff salary (C) Operating Costs with salary versus total number of instruments
 568 (D) Operating Costs with salary versus staff.
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 573 **Figure 9.** Funding Sources Metrics across the Regions versus Staff Number. (A) The Americas (B)
 574 Asia Pacific. (C) Europe & Africa.

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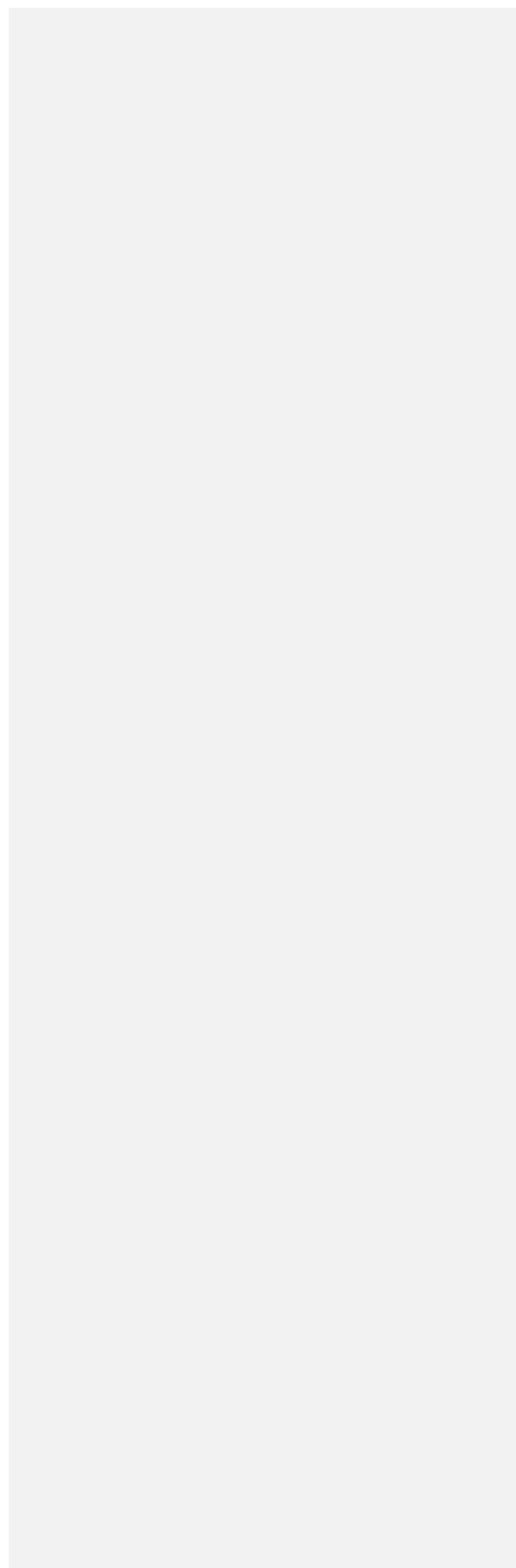
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Figure 10 . Advanced Microscopy Applications and Visualization/Data Analysis Approaches. (A) Advanced Microscopy Applications, (B) Visualization and Data Analysis.

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Global Core Microscopy Facility Distribution Heatmap (By Country)

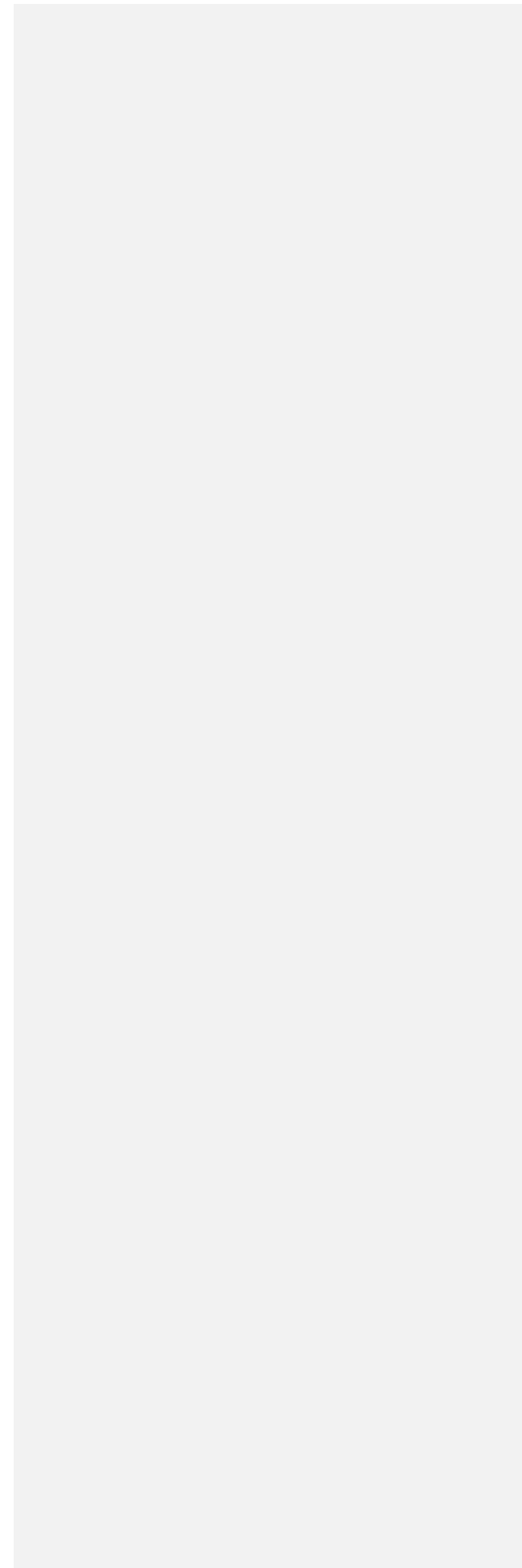


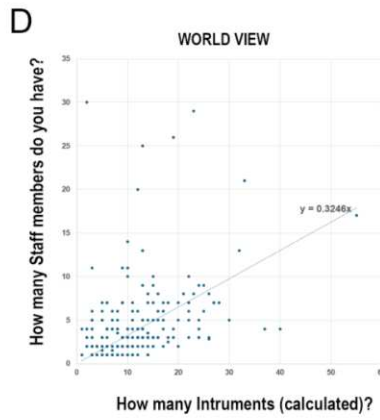
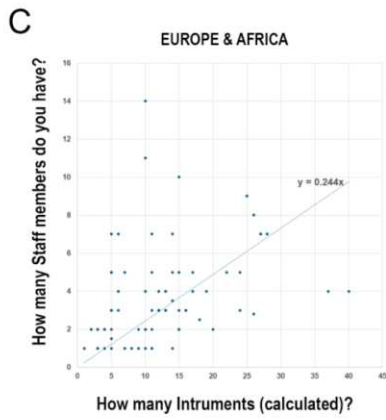
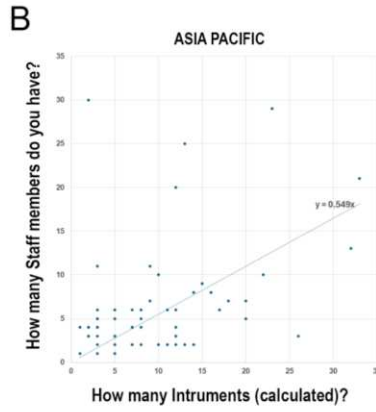
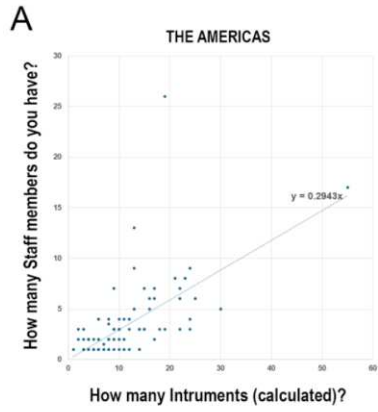
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633 **Supplementary Figure 1.** Microscopy Survey Demographic Country Heatmap. This global
634 Microscopy core facility survey included 241 participants from 24 countries.
635 See Figure 1 for the country allocation into the 3 distinct geographical regions, “The Americas”,
636 “Europe & Africa” and “Asia Pacific”.
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Microscopy Survey

Supplementary Figure 2 – All Charts

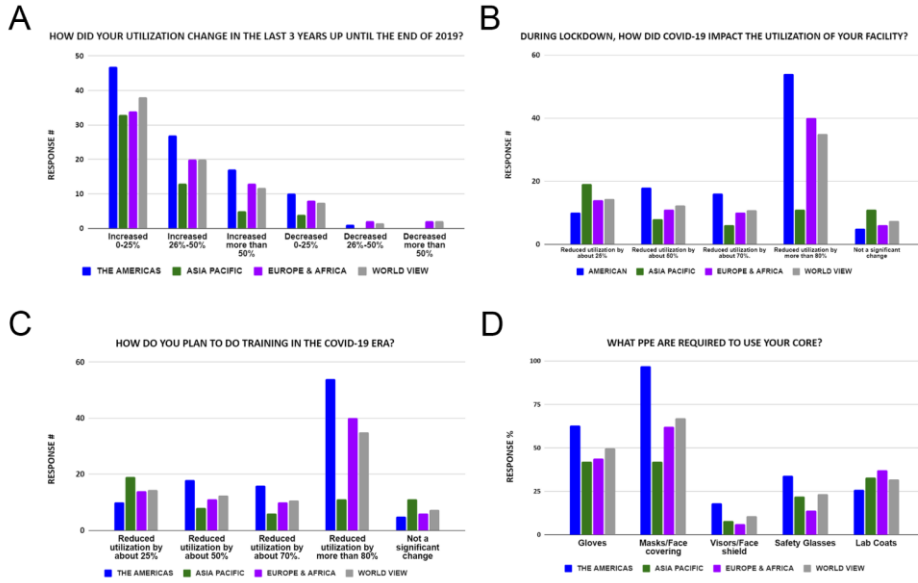
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644 **Supplementary Figure 2.** See Supplementary PowerPoint with All Questions as Charts
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 647 **Supplementary Figure 3** . Staff vs How many instruments (A) The Americas, (B) Asia Pacific,
 648 (C) Europe & Africa, (D) World View

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 660 **Supplementary Figure 4** . Impact of COVID. (A) Utilization in prior 3 years, (B) Utilization
 661 during lockdown, (C) Training during COVID, (D) PPE used during COVID.