**Educating for Reproducibility: Pathways to Research Integrity**

**Project Narrative**

Cultivating the next generation of ethical researchers is a key component of fostering a culture of research integrity. Research integrity training primarily focuses on the responsible conduct of research, covering a wide swath of topics designed to instill values and ethical and moral judgement into our trainees.1 Using these values and ethical frameworks, trainees can be expected to make better choices when confronted with difficult choices.2 One area that responsible conduct of research courses have covered less, if at all, is reproducibility.

Reproducibility and replicability are cornerstones of research integrity and science, but recent concerns about the reproducibility “crisis” led to increased public, scientific, and governmental focus on this topic.3-6 Indeed, the NIH now requires that researchers specifically address rigor and reproducibility in grant applications.7 Though the NIH provides answers to frequently asked questions, a rigor and reproducibility resources page, and some training materials, largely researchers face training themselves about what reproducibility means for their research.

To date, concerns about research reproducibility have surfaced in dozens of disciplines, from economics8 to neuroscience.9 In the health sciences, these concerns have been most evident in the preclinical drug development sphere, where multiple studies show a significant lack of reproducibility, as much as 89 percent.10,11 Large-scale replication projects like the ongoing Reproducibility Cancer Biology project and the Reproducibility Psychology project have also highlighted challenges with reproducibility in those fields.12,13 In addition to these types of replication projects, individual researchers and research are often publicly questioned about reproducibility concerns, shaping widespread, public conversations about the integrity and even validity of science.14-18 Though outright fraud and serious misconduct remains rare, these replication projects and cases confirm that a much larger proportion of scientists use “questionable research practices,”19 such as data dredging (p-hacking)20 or HARKing (hypothesizing after results are known).21

Achieving reproducible and replicable science is a challenge because of the sheer complexity of science. Every stage of research, from design to publication, can present opportunities for research irreproducibility. Even defining reproducibility and replicability remains difficult, though three general areas of reproducibility are often discussed: methods reproducibility, results reproducibility, and inferential reproducibility.22 Within each of these areas fall dozens of potential complications, from poor study design to manipulation of results to achieve significant results.

Available training tends to focus on technological aspects of reproducibility, often centered on producing reproducible code and analysis. Workshops, such as those offered by “carpentries” groups, help researchers quickly learn tools to create workflows to enhance computational reproducibility or manage data appropriately.23-25 The NIH offers several training modules that prompt researchers to think more broadly about concepts in reproducibility, such as sex and gender differences in research.26 Movement towards more reproducible research and less research waste may require a change in educational and training paradigms, however, especially to reach the next generation of researchers. Beyond curricula, it may also impact how we support and offer guidance to students and trainees in our institutions.

**Description of Project**. We propose to host a conference focusing on reproducibility education and training at all levels of education, from undergraduate to continuing education for principal investigators. We plan to bring together educators, researchers, and administrators from a wide range of disciplines and institutions to discuss the challenges, opportunities, and existing programmatic examples in reproducibility education and outreach.

This conference proposal is based upon the success of and lessons learned from two previous national conferences focused on other aspects of research reproducibility chaired by the principal investigator, Melissa Rethlefsen, at the University of Utah. Briefly, in November 2016, the University of Utah’s Spencer S. Eccles Health Sciences Library (“EHSL”) sponsored the multidisciplinary Research Reproducibility Conference (“UtahRR16”).27 This conference was designed to explore ways institutions can help “make research true,” a concept inspired by Dr. John Ioannidis.28 Over 200 attendees participated in person, plus another 100 viewed the live stream on YouTube. Feedback from the event was positive, and attendees encouraged us to offer more networking opportunities, practical tips and examples, more conferences and learning sessions, and movement toward “meaningful action and change.”29

As a result of feedback from the conference, we established a Research Reproducibility Coalition with participants across campus to help lead institution-wide discussions about ways to promote and foster a reproducibility culture. In addition, we created a year-long Grand Rounds Research Reproducibility (#UtahGRRR) series with weekly lectures from a wide range of disciplines to bring together researchers and students interested in exploring reproducibility topics.30 Lastly, we hosted the second Research Reproducibility Conference, “Building Research Integrity through Reproducibility,” in June 2018 (“UtahRR18”).31 The conference was funded in part by the Office of Research Integrity (ORIIR170034-01-00). In addition to the conference itself, individuals seeking additional training could elect to register for a week-long course that culminated in the conference.32 The week-long course, a partnership between EHSL and the University of Utah’s Department of Philosophy, prepared attendees for the conference by introducing concepts and problems in reproducibility as well as practical tools to enhance their own workflows. The course was offered for two course credits or 33 continuing education credits through various professional disciplines. It was sponsored in part by the National Network of Libraries of Medicine, MidContinental Region, under cooperative agreement number UG4LM012344.

Results from UtahRR16 were published in Journal of the Medical Library Association29, and results from UtahRR18 were disseminated at regional and national presentations. Materials from both conferences (UtahRR16 and UtahRR18), the course, and UtahGRRR were widely promoted and disseminated via social media channels, including the official University of Utah Health channels. Videos from all events were added to the EHSL YouTube channel (<https://www.youtube.com/channel/UCDYTPnuWBAVsOVGJ0LTmTgw>). UtahRR16 posters and selected presentations were also published on the EHSL’s e-channel platform for broad distribution.27 We encouraged UtahRR18 poster presenters to publish their posters using OSF (<https://osf.io/search/?q=%22UtahRR18%22>). Course instructors shared their materials online (<https://vickysteeves.gitlab.io/2018-uutah-repro/index.html>).

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| **Content** | **Views on YouTube (as of March 30, 2019)** |
| UtahRR16 (7 videos) | 217 |
| UtahGRRR (22 videos) | 3,489 |
| Course (7 videos) | 880 |
| UtahRR18 (1 video) | 603 |

The primary outcomes for UtahRR18 were to build awareness of research reproducibility, provide a forum for discussion, and provide opportunities for researchers to network and build collaborative relationships. Post-conference and post-workshop evaluations were positive, indicating that we achieved those goals. However, conversations at UtahGRRR, combined with evaluative comments from the UtahRR18 participants made it clear that they perceived gaps in the content, particularly around mentoring, power in student/faculty relationships, and standing up to bad practices. As one attendee noted,

“There are a lot of ways to tackle research reproducibility. The one I found really compelling and would like to see a deeper dive in in future conferences is the role of mentoring in developing scientists to be more aware of the need for research reproducibility.”

Another attendee commented that they would like to see a

“student focused panel or student moderator for the ‘next generation’ of scientists. This could be in the form of a panel or interactive session for undergrad, grad students and post-docs to ask questions or provide ideas to senior faculty or panelists regarding their concerns or a student moderating a discussion on how to stand up to a PI who has mildly questionable behavior or what resources exist to help students and their faculty work together to improve integrity.”

This type of direct feedback matched what we heard at the Coalition meetings and UtahGRRR. Students, particularly graduate students, were desperate for solutions to what the respondent above called “mildly questionable behavior.” Pathways for students were clear if outright fraud or research misconduct was being conducted, but not if they sensed that faculty were asking them to commit lesser, or more common, questionable practices like data dredging, p-hacking, HARKing, or perform underpowered studies.

Though we saw these concerns repeatedly over our four years working in this space, we also saw positive signs that individual faculty were taking steps to inculcate a culture of reproducibility into their students right from the undergraduate curriculum. We connected with faculty who led undergraduate students through entire replication studies of published linguistics research, faculty who made reproducible research practices the center of their neurosciences courses, and faculty who taught seminar series on cell line authentication. In addition, as EHSL became more recognized for our educational efforts in these areas, team members were frequently asked to provide lectures and workshops for various groups locally and nationally, including curriculum-embedded sessions.33 At the University of Florida, we are similarly engaged in educational efforts, such as the 1st Annual UF Data Symposium, "Enabling Data Reproducibility and Sustainability," hosted by the George A. Smathers Libraries in 2018, and workshops on data management, R, and OSF, for example.

Though these are positive steps, very little is formally published about educating learners about reproducibility, either conceptually or how to practice reproducible research. Psychology education is the exception, where teaching reproducibility concepts and asking students to conduct replication studies is getting considerable uptake.34-40 Some educators are contributing to a collection of open science and reproducibility education syllabi41, though only a handful of these courses or approaches have been formally disseminated.35 Data science or computationally-focused classes are also emerging in several disciplines, including the health sciences42, though more often life and health sciences disciplines appear to rely on bootcamps, hack weeks, workshops, and symposia like UtahRR16 and UtahRR18.23,24,33,43,44 Though there is some evidence that short-term training sessions like these can be efficacious23,24,43, there is also evidence to the contrary.45 As one team of educators stated,

“Bootcamps and hack weeks can be useful, but their starting point is an attempt to augment an aging curriculum that does not recognize the need for training in accurate, effective, and reproducible computation. We should fix this by changing our curriculum; learning to work this way takes time, practice, and support, and we teach it best with substantial commitment from students and instructors.”42

While we agree that commitment to principles of reproducibility does require commitment from students and instructors, we also believe it requires commitment from institutions.

Reproducibility cuts across all research disciplines. The issues and many of the solutions are discipline-agnostic, similar to other responsible conduct of research education. This is why coding and data science-focused courses emerged in this space; they are helpful to nearly all researchers. Though these courses can provide the tools and skills, however, they cannot help answer some of the larger questions about how institutions can and should support students navigating questionable research practices questions or similar ethical and policy questions. We believe a blend of practical and ethical training is required to fully educate researchers about reproducibility and its role in research integrity. How to best train researchers in this area is still unknown, however, especially since all levels of researcher may require education and skill building in these areas.

This conference is designed to bring together experts and novices, researchers and educators, and students and administrators from multiple disciplines and institutions to explore pathways for research reproducibility through education. We intend to model the structure of this conference after the UtahRR16 and UtahRR18 conferences, with modifications based on previously received feedback. We will focus on positive approaches to research integrity, with reproducibility as the overarching framework. Below, we have listed potential speakers for each component of the agenda. Additional speakers will be identified by consultation with our planned advisory committee, which will also prioritize our speaker invitations. The proposed agenda is below:

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| Time | Session |
| 8:00 am – 8:30 am | Check in and networking breakfast |
| 8:30 am – 8:45 am | Opening remarks from institutional host(s) |
| 8:45 am – 9:45 am | Keynote  Theme: Educating for Reproducibility: Pathways to Research Integrity  Emphasis: Graduate student education or undergraduate student education in health sciences, sciences, or social sciences  Potential Speakers: John Ioannidis (Co-Director, Meta-Research Innovation Center (METRIC), Stanford University), Victoria Stodden (Associate Professor, University of Illinois at Urbana-Champaign), Brian Nosek (Executive Director, Center for Open Science), or representative from Berkeley Initiative for Transparency in the Social Sciences, Project TIER, Collaborative Replications and Education Project, or similar large-scale educational effort |
| 9:45 am – 10:15 am | Break |
| 10:15 am – 11:00 am | Panel: Educators  Theme: Learning Across Disciplines: Approaches to Develop Reproducibility Education  Emphasis: Undergraduate / Graduate Education  Potential Speakers: Brian Avery (Professor of Neuroscience, Biology, and Data Science; Westminster College), Rachel Hayes-Harb (Professor of Linguistics, Director of the Office of Undergraduate Research; University of Utah), Simine Vizire (Associate Professor of Psychology, University of California Davis), Jordan Wagge (Associate Professor of Psychology, Avila University), K. Jarrod Millman (Postdoctoral Researcher, Institute for Data Science; University of California, Berkeley), David Grainger (Distinguished Professor of Biomedical Engineering; University of Utah); Richard Ball (Professor of Economics, Co-Director of Project TIER, Haverford College); Others |
| 11:00 am – 12:00 pm | Paper Presentations  Theme: Educating for Reproducibility: Pathways to Research Integrity  Speakers: By Competitive Submission |
| 12:00 pm – 1:30 pm | Lunch and Poster Session |
| 1:30 pm – 2:15 pm | Panel: Students and Researchers  Theme: Students and Mentors  Emphasis: Student experiences and expectations; mentor guidance and supports  Potential Speakers: Graduate Students, Undergraduate Students, Post-Doctoral Fellows, Mentors (TBD) |
| 2:15 pm - 2:30 pm | Break |
| 2:30 pm – 3:15 pm | Panel: Administrators  Theme: Institutional Support  Emphasis: Institutional policies, student affairs officers, safety nets, and other resources to help students ensure integrity through reproducibility  Potential Speakers: Administrators, Research Integrity Officers, Students (TBD) |
| 3:15 pm – 4:00 pm | Roundtable Discussions  Theme: Training Gaps  Emphasis: Roundtable discussions to identify training gaps and potential solutions, arranged by interdisciplinary concept (e.g., basic principles, data science, statistics, study design, peer review, manuscript preparation, documentation, lab notebooks) |
| 4:00 pm – 4:15 pm | Break |
| 4:15 pm – 5:00 pm | Panel: Educators  Theme: Learning Across Disciplines: Approaches to Develop Reproducibility Education  Emphasis: Post-Graduate and Professional Education  Potential Speakers: Erin Becker (Associate Director for Data Carpentry); James M. DuBois (Professor of Medical Ethics and Professionalism, Washington University School of Medicine); Alison Antes (Assistant Director of the Center for Clinical and Research Ethics, Washington University); Tisha Mentnech (Research Librarian for Life Sciences & Research Metrics, North Carolina State University); Amy Riegelman, (Social Sciences Librarian, University of Minnesota); Gail Clement (Head of Research Services, Caltech Library); Nicole Janz (Assistant Professor, Faculty of Social Sciences, University of Nottingham); Roger Peng (Associate Professor of Biostatistics, Yale University); Edward Miguel (Director, Berkeley Initiative for Transparency in Social Sciences; University of California, Berkeley); Others |

We propose a set of panels to explore components of reproducibility education. First, separate panels of educators will discuss undergraduate and graduate educational strategies, and post-graduate and professional education strategies. Separating these groups of learners will enable attendees to learn more about specific methods for incorporating reproducibility concepts and methods directly into credit-bearing courses as well as learning and mentoring opportunities designed for those already in practice. Another panel will include learners themselves, both to discuss the challenges they perceive in their learning environments, but also to highlight what types of training, mentoring, and supports they feel are necessary to foster a culture of reproducibility. A fourth panel will include administrators, such as research integrity officers and student affairs administrators, who will address student supports and pathways for success. The panels will be framed by an opening keynote speaker discussing overall pathways for reproducibility education and training. Submitted content and roundtables will fill the remainder of the day.

The schedule and format is directly based upon feedback from attendees at UtahRR16 and UtahRR18. This combination of expert panels, submitted papers and posters, roundtable discussions, and keynote speaker will enable participants to learn from a diverse set of perspectives and viewpoints from national and international experts. Attendees will be able to deeply engage in the conversation in the roundtables and poster sessions, a form of peer-to-peer learning. In addition, we propose using Slido for the three panel discussions. Slido is a tool for anonymously soliciting questions from audience members, including those not physically in attendance. Attendees can “vote up” questions so that panel moderators can select questions that appeal to the most audience members. We used Slido at UtahRR18, and we received very positive feedback from participants.

We will create a conference web site to both advertise the conference and store all of the materials produced by the conference. The web site will be hosted by the George A. Smathers Libraries. We will also advertise the conference using email mailing lists and social media. We will use a branded hashtag for the event (i.e., #RR2020) as well as promote the event using other Twitter hashtags (e.g., #MakeResearchTrue, #reproducibility, #openscience) using multiple University of Florida, personal, and partner library Twitter accounts for dissemination. We will livestream the conference so that those unable to attend in person can still participate. Using Slido and Twitter hashtags, we will also be able to engage online participants in question and answer sessions and networking. We will work with other academic libraries nationally to host viewing parties in an effort to build local communities around these topics. The conference recording(s) will be made available on the Health Science Center Libraries’ YouTube channel (<https://www.youtube.com/user/UFHSCLibraries>). We will also encourage speakers and presenters to upload their presentations and posters to the Open Science Framework (“OSF”) web site46 using the conference hashtags. For local presenters, we will also encourage them to submit their materials to IR@UF, the University of Florida’s institutional repository (http://ufdc.ufl.edu/ufir).

We anticipate about 150 attendees in person, with additional attendees via our livestreamed video, Slido, and Twitter conversations. We plan to hold the conference at the University of Florida’s J. Wayne Reitz Union (“Reitz Union”), which has ample facilities for all components of the planned conference. The Reitz Union spaces include large ballrooms and auditoriums appropriate for plenary sessions, panels, and posters, and small conference rooms for breakout sessions, should we receive enough paper presentation submissions. The Reitz Union provides audiovisual support, lighting, and labor for events.

**Outcomes.** The primary outcome for the conference will be increased knowledge of educational approaches to foster research integrity through reproducibility. The secondary outcomes will be to give attendees networking opportunities for brainstorming and collaboration, build awareness of reproducibility as a component of research integrity and responsible conduct of research education, and provide a forum for discussion. To measure outcomes, we will conduct a post-conference survey to capture participant feedback, determine anticipated behavior changes, and assess perceived changes in knowledge of educational approaches for increasing research reproducibility. We will seek to publish the proceedings of the conference as a journal article in addition to publishing and widely disseminating the products from the conference, namely all videos of conference sessions and any presentations and posters authors choose to deposit in OSF or the IR@UF.

**Project Management**. The project team will be led by PI Rethlefsen, who will have primary responsibility for leadership of the project, progress monitoring, reporting, and communication with HHS/OASH. PI Rethlefsen will be the primary contact with the proposed advisory committee, in conjunction with other members of the planning team. The planning team will also include Key Personnel Plato Smith, Hannah Norton, Daniel Maxwell, Zhuoxi “Joe” Wu, Sarah Meyer, a Reproducibility Librarian (TBD), and an event planner to be determined. The Key Personnel will be responsible for coordinating outreach, marketing, liaising with speakers, managing the paper and poster submission and announcement process, assessment, and establishing and maintaining the web site. The Event Planner will be responsible for coordination of facilities, audiovisual needs, ensuring timely reimbursements and honoraria distributions to speakers, catering, preparation of marketing materials, registration, and administration of the evaluations. Together, the planning team will also work with the advisory committee to solicit input on speakers, topics, and conference content in general.

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| Role | Name | Responsibilities |
| PI | Melissa Rethlefsen | Leadership, Reports, Progress Monitoring |
| KP | TBD | Facilities, Audiovisual, Financial Coordination, Registration, Evaluation Administration, Catering, General Support |
| KP | Plato Smith | Outreach, Marketing, Liaison to Speaker(s) |
| KP | Hannah Norton | Outreach, Marketing, Liaison to Speaker(s), Paper/Poster Submissions |
| KP | Daniel Maxwell | Outreach, Marketing, Liaison to Speaker(s) |
| KP | Joe Wu | Outreach, Marketing, Liaison to Speaker(s) |
| KP | Sarah Meyer | Outreach, Marketing, Liaison to Speaker(s), Assessment |
| KP | Reproducibility Librarian TBD | Outreach, Marketing, Liaison to Speaker(s) |

The planning team will also draw upon additional staff and faculty within the George A. Smathers Libraries for additional support. This will include the Information Technology department, which provides library faculty with resources for web site creation; the Fiscal Services team, which will handle all finances in coordination with the planning team; the Marketing Team at the Health Science Center Library, which oversees all social media and other marketing for the Health Science Center Library; the Social Media Specialist for the George A. Smathers Libraries, who oversees all Libraries-wide social media efforts; and the Director of Communications, who manages all Libraries-wide communications.

We will create a local advisory committee, comprised of 3-5 researchers and educators interested in reproducibility, research integrity, data science, and related topics. The advisory committee will provide input on general conference planning, marketing, and speaker identification and selection. We have identified potential members for the advisory committee, drawn from multiple disciplines. These individuals have provided letters of support indicating their willingness to commit time and expertise to this project.

**Evaluation**. We will measure immediate impact of the conference using a post-conference survey. We will capture feedback on the conference itself, as well as participants’ perceived changes in knowledge. We will assess whether the conference successfully provided networking and discussion opportunities, and whether participants’ awareness of reproducibility as a component of research integrity education increased. We will also ask participants for any additional training needs and suggestions for moving the conversation forward at the University of Florida and beyond. To conduct the evaluation, we will use REDCap, which is provided to University of Florida faculty through the Clinical & Translational Science Institute.

**Dissemination**. As noted above, we will livestream the conference and use Twitter to engage a wider audience by live tweeting the event. We also plan to provide the conference recording(s) on the Health Science Center Libraries’ YouTube channel (<https://www.youtube.com/user/UFHSCLibraries>). We will also encourage speakers and presenters to upload their presentations and posters to the Open Science Framework (“OSF”) web site46 using the conference hashtags, and we will link to those that are available on the conference web site. For local presenters, we will also encourage them to submit their materials to IR@UF, the University of Florida’s institutional repository (<http://ufdc.ufl.edu/ufir>). These will be similarly linked from the conference web site. We will also plan to publish the proceedings of the conference as a journal article.

**Organizational Capability Statement**. The University of Florida is a large land-grant, sea-grant, and space-grant public institution located in Gainesville, Florida and serving over 50,000 undergraduate, graduate, and professional students annually. The University has sixteen colleges, including six health sciences schools (Medicine, Dentistry, Nursing, Pharmacy, Public Health and Health Professions, and Veterinary Medicine), an affiliated health system, and over 150 research institutes. The George A. Smathers Libraries (“Libraries”) operate across all schools and locations. There are three major campus libraries, the Health Science Center Library, Marston Science Library, and Library West (supporting humanities and social sciences). The Libraries have an interdisciplinary research support team called ARCS (Academic Research Consulting & Services), which actively supports data management, informatics, data science, and reproducibility. Library faculty also lead a campus-wide Data Management Curation Working Group (led by KP Plato Smith) and Informatics & Analytics Task Force (co-led by KP’s Daniel Maxwell and Sarah Meyer).

PI Rethlefsen is an Associate Dean for the Libraries, and is primarily responsible for the Health Science Center Library in Gainesville and the Borland Library, serving the UF Health Jacksonville campus, including the Colleges of Medicine, Pharmacy, and Nursing and the health system locations in Jacksonville. She also shares responsibility for the ARCS team, directly supervising the Head of ARCS. As previously stated, PI Rethlefsen led two other large scale research reproducibility conferences at her previous institution, the University of Utah. At the University of Florida, she developed the Rigor and Reproducibility session for the Biomedical Sciences graduate-level Responsible Conduct of Research course.

KP Plato Smith is the Libraries’ Data Management Librarian and ARCS team member. KP Smith spearheaded the 1st Annual Data Symposium, “Enabling Data Reproducibility and Sustainability,” sponsored by the Libraries. He also teaches campus-wide workshops on data management and data science topics. Hannah Norton is a Team Lead within the Health Science Center Libraries and has expertise in health sciences data management. KP Norton was a mentor in the “Biomedical and Health Research Data Management for Librarians” class offered by the National Training Office, National Network of Libraries of Medicine, and has substantial experience in event planning at UF. KP Daniel Maxwell is the Informatics Librarian at the Marston Science Library and an ARCS team member. KP Maxwell teaches R and other informatics courses for the campus. KP Joe Wu is the Bioinformatics Librarian at the Health Science Center Library and an ARCS team member. He teaches R and other bioinformatics tools for the campus. KP Sarah Meyer is the Dentistry Liaison Librarian at the Health Science Center Library. KP Meyer works in biomedical informatics and is creating a public health data catalog in partnership with the Clinical & Translational Science Institute. The Health Science Center Library is currently recruiting a new Reproducibility Librarian position. When filled, we anticipate the new hire to play a key role in planning and executing the conference. Lastly, we will hire a part-time event planner to help with the facilities, catering, and other more technical details of the event.

We will partner with other groups on campus to promote the conference, including the Clinical & Translational Science Institute and the Informatics Institute. We will seek additional partnerships with the student-led UF Data Science and Informatics group; the UF Carpentries Club; the R Users Group for Gainesville; R-SSIG, an R interest group in the social sciences at UF; and R-GATORS.

**Responsible Conduct of Research Plan**. PI Rethlefsen and KP’s Smith, Norton, Maxwell, Wu, and Meyer have all completed training in responsible conduct of research, conflicts of interest, use of human subjects, research misconduct, authorship and publication, data management, peer review, and research collaborations as related to the conference through the Collaborative Institutional Training Initiative (CITI Program), NIH’s Protecting Human Research Participants Online Training, and/or local IRB training. Incoming team members will be required to complete these trainings as well. The Office of Research at the University of Florida provides guidance on which trainings are required for each team member.

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