

CURRICULUM VITAE

PERSONAL PROFILE

SHAFIQ UR REHMAN [HTTPS://ORCID.ORG/0000-0002-1265-3442](https://orcid.org/0000-0002-1265-3442)

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RESEARCH INTERESTS

Viral Evolution, Pathogenesis of Viral Diseases, Bacteriophage Therapy, Production of Biomolecules, Genome Editing, Veterinary Vaccines

EDUCATION

1. PhD, Virology, (Sep-2007 to Feb-2012)

University of Nottingham, Nottingham, UK

Thesis Title: The nature and consequences of the hepatitis C Virus E1E2 envelope gene variability

2. Bachelor of Science, Microbiology and Molecular Genetics (2002-2006)

University of the Punjab, Lahore, Pakistan.

CERTIFICATIONS

1. Agri Innovation: From Development to Scale. Feb-2022. Awarded by Wellspring (40 National Hours).

WORK EXPERIENCE

1. **Associate Professor (Tenured)**, Institute of Microbiology and Molecular Genetics, University of the Punjab, Lahore (25-August 2020 till date)
2. **Assistant Professor on TTS**, Department of Microbiology and Molecular Genetics, University of the Punjab, Lahore (16-April 2012 to 24-August 2020)
3. **Lecturer**, Department of Microbiology and Molecular Genetics, University of the Punjab, Lahore (29 May, 2007 to 15 April 2012)

RESEARCH GRANTS

- Title: Development of Bacteriophage Biobank against major pathogenic bacteria of poultry, and poultry borne human pathogenic bacteria. Funding Agency: Pakistan Science Foundation. **Funding Amount: 4226064 PKR, 2022-25 (CO-PI). In-Progress**
- Title: Biological control of mastitis using bacteriophage cocktails prepared in stem cells conditioned media: bio control potential and field trials. **Funding Agency:** Punjab Agricultural Research Board. **Funding Amount: 23846000 PKR, 2022-25 (Team Member). In-Progress**

- **Title:** Isolation and Characterization of Bacteriophages against Multi-Drug Resistant Mycobacterium tuberculosis. **Funding Agency:** Higher Education Commission, Pakistan. **Funding amount: 7042200 PRK, 2022-2025 (Co-PI). In-Progress**
- **Title:** Development and commercialization of antibiotics alternatives for Pakistani Poultry production. Funding Agency: International Development Research Centre (IDRC) Canada. **Funding Amount CA\$2,804,100 (2019-2023) (collaborative research project between Purdue University US, UVAS Lahore and Punjab University Lahore)-PU Project Manager-Completed successfully**
- **Title:** Isolation, Purification and Characterization of Novel Peptides from Common Aero-allergens encountered in Pakistan and their Association with Immuno-genetic Factors of Allergy Patients. **Funding Agency:** Higher Education Commission, Pakistan. **Funding amount: 4300450 PRK, 2017-2020 (Co-PI). -Completed successfully**
- **Title:** Isolation and Characterization of Bacteriophages against the Multidrug resistant bacterial pathogens to be used for phage therapy. **Funding Agency:** Higher Education Commission, Pakistan. **Funding amount: 68,13,922 PRK, 2016-2019 (PI). -Completed successfully**

PATENTS

Submitted

1. **Paul Ebner, Shafiq ur Rehman and Zafar Hayat.** Antibiotic-Free Treatment for Salmonella Gallinarum in Poultry using Encapsulated Poly-Bacteriophage Therapy. **Disclosure submitted to US patent Office in year 2022.**
2. **Paul Ebner, Abdul Hanan, Zafar Hayat, and Shafiq ur Rehman.** Antibiotic-Free Treatment for Avian Pathogenic E. Coli using Encapsulated Poly-Bacteriophage Therapy. Submitted in year 2023.

In Preparation

1. Shafiq ur Rehman and Hafsa Tahir. Lytic Bacteriophages and use thereof for the treatment or prevention of infection caused by salmonella gallinarum to be submitted in Pakistan Patent Office
2. Shafiq ur Rehman, Zulqarnain haider and Hafsa Tahir. Lytic Bacteriophages and use thereof for the treatment or prevention of infection caused by Clostridium perfringens in Poultry. To be submitted in Pakistan Patent Office.

3. Shafiq ur Rehman and Hafsa Tahir. Recombinant Bacteriophages and use thereof for the better treatment or prevention of infection caused by salmonella gallinarum. To be submitted in Pakistan Patent Office.
4. Shafiq ur Rehman, Hamza Tahir and Abdul Basit. Recombinant deletion mutant of Salmonella Gallinarum and their use as vaccine for prevention of chicken Salmonellosis. To be submitted in Pakistan patent Office.

RESEARCH EVALUATION ASSIGNMENTS PERFORMED

- Evaluated several projects for Paksitan Science Foundations
- Evaluated several projects for National Institute of Health Paksitan for their 2022 call.
- Evaluated research projects for British Society for Antimicrobial Chemotherapy for their Covid-19 Grant Call-2019 and 2020
- Reviewed research articles for famous research journals in the area of Microbiology and Virology

RESEARCH TECHNIQUES WITH HANDS ON EXPERIENCE

- Aerobic and anaerobic culturing
- Isolation and characterization of bacteriophages against aerobic and anaerobic bacteria
- Mammalian cell culture
- General and real-time PCR, RT-PCR, Site directed Mutagenesis
- NGS sequence assembly, annotation, and genome Analysis
- Cloning, expression and protein purification
- Genome editing through different modern ways (CRISPR, Golden Gate, Gibson, NEB-Assembly Master-mix)
- Animal Experiments (Mice rats and chickens)
- ELSIA
- Western blotting
- Pseudoviral particle production
- Designing and making live attenuated poultry vaccine
- Bacteriophage genome engineering.

CONFERENCES ORGANIZED

1. Dr. Shafiq ur Rehman organized two days workshop, "Workshop on Isolation and Characterization of Bacteriophages for Phage Therapy" at the University of the Punjab on 17-18 March 2023

2. Dr Shafiq ur Rehman organized three days international conference, “MMG-2018-A conference on Microbiology and Molecular Genetics” at the University of the Punjab, in collaborations with Department of Allied Health Sciences, The Superior College Lahore, on 7-9 Feb 2018.
3. Dr Shafiq ur Rehman organized two days workshop, “Advances in Phage therapy” at Department of Microbiology, Hazara University, Mansehra in Collaboration with department of Microbiology and Molecular Genetics, University of the Punjab, on 4-5 Apr 2017.
4. Dr Shafiq ur Rehman organized one day pre conference workshop, “isolation and propagation of bacteriophages” at Abbottabad University of Science and technology Hawalain on 19 Dec 2016.
5. Dr. Shafiq ur Rehman organized 4 days 10th Biennial International Conference of Pakistan Society for Microbiology, Exploring Microbes for Future Endeavors organized by MMG department in collaboration with IBA and ORIC, University of the Punjab Lahore and American Society for Microbiology held at the University of the Punjab, Lahore on 25-28 March, 2015.
6. Dr Shafiq ur Rehman organized the conference titled: Bio-physiochemical basis for the Technopreneurship organized by the Dept. of Microbiology and Molecular Genetics and Institute of Business Administration, university of the Punjab on 2-3 April 2013.

STUENTS SUPERVISED

Sr. No.	Student's Name	Class	Thesis Title	Year
1	Iqbal Ahmed Alvi	Post-Doc	In research Project, ”Development and commercialization of antibiotics alternatives for Pakistani Poultry production” (In Progress)	2022-2023
2	Basit Ali	Post-Doc	In research Project, ”Development and commercialization of antibiotics alternatives for Pakistani Poultry production” (Finished)	2019-2021
3	Muhammad Zulqarnain	PhD	Development of CRISPR-Cas9 mediated vaccine candidate by knocking out virulent genes in Avian pathogenic <i>Escherichia coli</i> (In Progress)	2021-2025
4	Muhammad Ahsan Shafiq	PhD	Assessment of Recombinant Bacteriophage Lytic Proteins against Multi-Drug Resistant Bacteria (In Progress)	2020-2024
5	Kanza Batool	PhD	Isolation and characterization of Bacteriophages against Hospital Acquired Extended Spectrum Beta-Lactamases (ESBL) producing <i>Escherichia Coli</i> (In Progress)	2018-2023
6	Ayesha Munir	PhD	Assessment of Bacteriophages to Control Poultry Origin Non-typhoidal Salmonella species (In Progress)	2018-2023
7	Muhammad Asif	PhD	Assessing the Potential of Engineered Bacteriophage Based Lytic Enzymes and Membrane Permeabilizers to Tackle the Outer Membrane Barrier of Multi-Drug	2017-2023

			Resistant Gram- Negative Bacteria (Thesis Submitted)	
8	Rabia Tabassum	PhD	Assessment of bacteriophages as therapeutic agent against multiple drug resistant pathogenic bacteria (Thesis Submitted)	2016-2023
9	Iqbal Ahmed Alvi	PhD	To assess the efficacy of bacteriophages against the antibiotic resistant <i>Pseudomonas auroginosa</i> (Completed)	2015-2019

PUBLICATIONS

Total Impact Factor: 103

➤ Publications with first author or corresponding author

1. Munir A, Ilyas SZ, Tahir H, Basit A, Haider Z, Rehman SU. PCR based early detection and antibiotic resistance pattern of Salmonella Gallinarum isolates from Pakistan poultry. J Microbiol Methods. 2023:106709. **2.1 X**
2. Asif, M., I. A. Alvi, M. Waqas, A. Basit, F. A. Raza and S. U. Rehman (2023). "A K-17 serotype specific Klebsiella phage JKP2 with biofilm reduction potential." Virus Res 329: 199107. **4.9- W**
3. Hamza Tahir, Abdul Basit, Hafsa Tariq, Zulquernain Haider, Asim Ullah, Zafar Hayat, and Shafiq Ur Rehman. 2022. Coupling CRISPR/Cas9 and Lambda Red Recombineering System for Genome Editing of Salmonella Gallinarum and the Effect of ssaU Knock-Out Mutant on the Virulence of Bacteria. Biomedicines. 10: 12: 3028. <https://doi.org/10.3390/biomedicines10123028>. **4.3- W**
4. 2. Rabia Tabassum, Abdul basit, Muhammad Asif, Iqbal Ahmed Alvi, Shafiq Ur Rehman. 2022. TSP, a virulent Podovirus, can control the growth of Staphylococcus aureus for 12 hours. Scientific Reports. 12:10008. <https://doi.org/10.1038/s41598-022-13584-5> **4.4- W**
5. Abdul Basit, Tahir H, Haider Z, Tariq H, Ullah A and Rehman S U. 2022. CRISPR/Cas9 based deletion of SpvB gene from Salmonella Gallinarum leads to loss of virulence in chicken. Frontiers in Bioengineering and Biotechnology. <https://doi.org/10.3389/fbioe.2022.885227>. **5.4- W**
6. Syeda Z.I, Tariq H, Basit A, Tahir H, Haider Z, and Rehman S. U. 2022. SGP-C: A broad host range Temperate Bacteriophage; against Salmonella Gallinarum. Frontiers in Microbiology. <https://doi.org/10.3389/fmicb.2021.768931> **4.7- W**
7. Zulquern H, Ali T, Ullah A, Basit A, Tahir H, Tariq H, Ilyas S Z, Hayat Z, Rehman S U. 2022. Isolation, toxinotyping and antimicrobial susceptibility testing of *Clostridium perfringens* isolated from Pakistan poultry. Anaerobe. 73(2022): 1-7. <https://doi.org/10.1016/j.anaerobe.2021.102499> **2.1-W**
8. Basit A, Karim AM, Asif M, Ali T, Lee JH, Jeon JH, Rehman Su, Lee SH. 2021. Designing Short Peptides to Block the Interaction of SARS-CoV-2 and Human ACE2 for COVID-19 Therapeutics. Frontiers in Pharmacology., **12**(2310). <https://doi.org/10.3389/fphar.2021.731828> **5.1- W**
9. Asif M, Hafsa N, Iqbal A. A., Abdul B and Rehman S. U. 2021. Characterization of a lytic EBP bacteriophage with large size genome against Enterobacter cloacae. APMIS. 129 (8) 461-469. <https://doi.org/10.1111/apm.13138> . **2.8-W**

10. Basit A, Qadir S, Qureshi S and Rehman S U. 2021. Cloning and expression analysis of fused holin-endolysin from RL bacteriophage; Exhibits broad activity against multi drug resistant pathogens. *Enzyme and Microbial Technology*. 149 (2021) 109846, 1-9. <https://www.sciencedirect.com/science/article/pii/S0141022921001046>. **3.2-X**
11. Ali. T.; Basit, A.; Karim, A.M.; Lee, J.-H.; Jeon, J.-H.; Rehman, S.u.; Lee, S.-H. 2021. Mutation-Based Antibiotic Resistance Mechanism in Methicillin-Resistant *Staphylococcus aureus* Clinical Isolates. *Pharmaceuticals* 2021, 14,(5), 420, 1-11. <https://doi.org/10.3390/ph14050420> **4.4- W**
12. Alvi. I. A., M. Asif and Rehman S. U. 2021. A Single dose of a virulent bacteriophage vB PaeP-SaPL, rescues bacteremic mice infected with multi drug resistant *Pseudomonas aeruginosa*. *Virus Research*. Vol 292. <https://www.sciencedirect.com/science/article/pii/S0168170220311576>. **4.9-W**
13. Basit A, Ali T, Rehman S.U. 2020. Truncated human angiotensin converting enzyme 2; a potential inhibitor of SARS-CoV-2 spike glycoprotein and potent COVID-19 therapeutic agent. *Journal of biomolecular structure & dynamics* 2020:1-10. <https://doi.org/10.1080/07391102.2020.1768150>. **4.0-X**
14. Iqbal A. A., M. Asif., R. Tabassum., R. Aslam., Z. Abbas., and Rehman S.U. 2020. RLP, a bacteriophage of the family Podoviridae, rescues mice from bacteremia caused by multi-drug resistant *Pseudomonas aeruginosa*. *Archives of Virology*. **165**:1289–1297 <https://doi.org/10.1007/s00705-020-04601-x> . **2.5- W**
15. Asif M., I. A. Alvi., R. Tabassum, and Rehman. S.U. 2020. TAC1, an Un-classified Myoviridae Bacteriophage against *Acinetobacter baumannii* with High Burst Size and Short Latent Period. *Archives of Virology*. **165** (2): 419-424 <https://doi.org/10.1007/s00705-019-04483-8> **2.5-W**
16. Tabassum R, Shafique M, Khawaja K A, Alvi I A, Rehman Y, Sheik, Abbas Z, **S U Rehman**. Complete genome analysis of a *Siphoviridae* phage TSK1 showing biofilm removal potential against *Klebsiella pneumoniae*. 2018. *Scientific Reports*. **8** (1):1-8. <https://doi.org/10.1038/s41598-018-36229-y>. **4.4 W**
17. Alvi I A, Asif M, Tabassum R, Abbas Z and **S U Rehman**. Storage of bacteriophages at 4°C leads to no loss in their titer after one year. 2018. *Pakistan Journal of Zoology*. **50** (6): 2395-2398. <http://dx.doi.org/10.17582/journal.pjz/2018.50.6.sc8> **0.5 Y**
18. Asif M, Alvi I A, and **S U Rehman**. Insight into *Acinetobacter baumannii*: pathogenesis, global resistance, mechanisms of resistance, treatment options, and alternative modalities. 2018. *Infection and drug resistance*. **11**. 1249-1260. <https://doi.org/10.2147/IDR.S166750> **3.6 W**
19. Muafia Shafique, Iqbal Ahmad Alvi, Zaigham Abbas and **Shafiq ur Rehman**. 2017. Assessment of Biofilm Removal Capacity of a Broad Host Range Bacteriophage JHP against *Pseudomonas aeruginosa*. *APMIS*. **125**. 579-584. <https://doi.org/10.1111/apm.12691> **2.8. W**
20. Tahir, A., M. Asif, Z. Abbas, and **S U Rehman**. 2017 Three Bacteriophages SA, SA2 and SNAF can Control Growth of Milk Isolated *Staphylococcal* Species. *Pakistan Journal of Zoology*. **49.2**:493-496. <http://dx.doi.org/10.17582/journal.pjz/2017.49.2.529.533> **0.5 Y**
21. Khawaja, K. A., Z. Abbas, and **S. U. Rehman**. 2016. Isolation and characterization of lytic phages TSE1-3 against *Enterobacter cloacae*. *Open Life sciences*. **11**:287-292. <https://doi.org/10.1515/biol-2016-0038> . **2.1 X**
22. **S. U Rehman**, M. Rauf, Z. Abbas, M.H. Hamid and I. Qadri. 2016. Role of Some Predominant Host immuno-modulators SNPs in Severity of HBV and HCV infection.

- Viral Immunology. 29, 10: 536-545. <https://doi.org/10.1089/vim.2016.0062> 2.2
Y
23. Khawaja, K. A., M. Rauf, Z. Abbas, and **S. U. Rehman**. 2016. A virulent phage JHP against *Pseudomonas aeruginosa* showed infectivity against multiple genera. *Journal of basic microbiology*. 56:1090-1097. <https://doi.org/10.1002/jobm.201500764> 3.1
X
24. Hamza, A., S. Perveen, Z. Abbas, and **S. U. Rehman**. 2016. The Lytic SA Phage Demonstrate Bactericidal Activity against Mastitis Causing *Staphylococcus aureus*. *Open Life Sciences* 11:39-45 <https://doi.org/10.1515/biol-2016-0005> 2.1 Y
25. Zainab, B. Z. Abbas. And **S. U. Rehman**. 2016. A Phage P.E1, Isolated from Hospital Sewage Reduces the Growth of *Escherichia coli*. *Biocontrol Science and Technology* 26: (2), 181-188. <https://doi.org/10.1080/09583157.2015.1086311> 1.3 X
26. **Rehman S U**, Jamil. N. and Hassain. S. 2007. Screening of different contaminated environments for polyhydroxyalkanoates-producing bacterial strains. *Biologia* 62:650-656. <https://doi.org/10.2478/s11756-007-0144-y> 1.4 Y
27. **Rehman S U**, Jamil. N. and Hassain. S. 2006. Characterization and Optimization of antibiotic resistant bacterial strains for polyhydroxyalkanoates. *Pakistan Journal of Agricultural Research* 19:81-86. https://www.academia.edu/28616616/characterization_and_optimization_of_antibiotic_resistant_Bacterial_strains_for_polyhydroxyalkanoates_PHAS_production?from_site_maps=true&version=2 Y

➤ **Publications as co-author**

1. T. Riaz, Z. Hayat, K. Akram, K. Saleem, H. U. Rehman, M. Azam, Z. Tariq, **S. U Rehman**, A. Meraj, U. Farooq and A. Shafi. 2023. Optimization of gallic acid-enriched ultrasonic-assisted extraction from mango peels. *Open Chemistry*. 21.1.1-13. <https://doi.org/10.1515/chem-2023-0116>. 2.3
2. H. Hamed, P. N. Pushparaj, **S. U. Rehman**, S. Al-Karim, S. Bazarah and I. Qadri. 2022. Deciphering the Significance of Plasma Chemokines as Prognostic Biomarkers in Pegylated IFN-A-2a /Ribavirin-Treated Chronic Hepatitis C Genotype 4 Patients. *Infectious Disorders - Drug Targets*. 22 (5): 58-62. 10.2174/1871526522666220303142837
3. S. Riaz, A. Hussain, M. Sohail, **S. U. Rehman**, N. Javed and Z. Abbas. 2021. Isolation and characterization of Vancomycin resistant *Staphylococcus aureus* (VRSA) from Intensive Care Units (ICU) of different hospitals in Lahore, Pakistan. *Advancements in life Sciences*:8(4) : 339-344. <http://www.als-journal.com/846-21/>.
4. S. Andleeb, N. Aslam, M. Habib, H. Zaman, S. Rehman, M. Imran and Z. Abbas. 2021. Transplacental hepato-curative potential of garlic against sodium arsenate induced oxidative stress in mice. 2021. *The Journal of Animal & Plant Sciences*. 31(1): Page: 86-96. <https://doi.org/10.36899/JAPS.2021.1.0196> 0.7
5. Madiha Habib, Shehar Bano, **Shafiq -ur Rehman**, Naveed Shahzad, Nauman Javeed, Muhammad Shahbaz Aslam, and Zaigham Abbas. 2020. Hepatoprotective Role of Swimming against arsenic induced oxidative stress in mice. *Journal of King Saud University-Science*:32: 822-827. <https://doi.org/10.1016/j.jksus.2019.02.011>. 3.7
6. K. Zahra, **S. Rehman**, N. Javed, M. S. Aslam and Z. Abbas. 2019. Extract preparation of major food allergens of pakistan and their protein profiling. *The Journal of Animal & Plant Sciences*.. 29(1): 91-98. <http://www.thejaps.org.pk/docs/V-29-01/12.pdf> 0.7

7. Abid Hussain, Farida Ahmed, Shyamali C Dharmage, **Shafiq ur Rehman** and Zaigham Abbas. 2019. Aero and food allergens sensitization patterns in a clinic-based sample in Pakistan: A one year retrospective study. *Pakistan Journal of Zoology*. 51 (4): 1429-1437 <http://dx.doi.org/10.17582/journal.pjz/2019.51.4.1429.1437> **0.5**
8. Syeda Zainab Ilyas, Rabia Tabassum, M. Haroon Hamed, **Shafiq ur Rehman**, and Ishtiaq Qadri. 2017. Hepatitis C Virus Associated Extrahepatic Manifestations in Lung and Heart and Antiviral Therapy Related Cardiopulmonary Toxicity. *Viral Immunology*. 30(9): 633-41. <https://doi.org/10.1089/vim.2017.0009> **2.2**
9. Madiha Hashmi, Abid Hussain, **Shafiq Ur Rehman**, Farida Ahmed, Shahbaz Aslam, Nadeem Afzal and Zaigham Abbas. 2017. Negative association of *HLA-DRB1*11* and *HLA-DRB1*12* alleles with aeroallergy patients visiting Allergy Centre (NIH), Islamabad, Pakistan. *Pakistan Journal of Zoology*. 49(5). 1563-1569. <http://dx.doi.org/10.17582/journal.pjz/2017.49.5.1563.1569> **0.5**
10. Maliha Uroos, Zaigham Abbas, Shumaila Sattar, Nigarish Umer, Arham Shabbir, **Shafiq Ur-Rehman**, and Ahsan Sharif. 2017. Comparison of anti-arthritic activity of n-hexane, ethyl acetate, and methanol extracts of *Nyctanthes arbor-tristis* using FCA-induced arthritic rat mode. *Evidence-Based Complementary and Alternative Medicine*. Volume 2017, Article ID 4634853, 13 pages. <https://doi.org/10.1155/2017/4634853>.
11. M. S. Aslam, K. Hanif, **S. U. Rehman**, I. Gull, M. A. Athar and Z. Abbas. 2016. Delignification of Paper Pulp by Purified Laccase from *Aspergillus Flavus*. *The Journal of Animal & Plant Sciences*. 29. 5:1399-1404. **0.7**.
12. Mehdi, R., A. Hussain, M. Ahsan, **S. U. Rehman**, M. S. Aslam, and Z. Abbas. 2016. Cloning and Expression of p40 Gene Isolated from Probiotic Bacteria of Dairy Origin. *Pakistan Journal of Zoology* 48:1769-1774. [http://zsp.com.pk/pdf48/1769-1774%20\(22\)%20QPJZ-0414-2015-F%208-4-16.pdf](http://zsp.com.pk/pdf48/1769-1774%20(22)%20QPJZ-0414-2015-F%208-4-16.pdf) **0.5**
13. Yousaf, S., A. Hussain, **S. U. Rehman**, M. S. Aslam, and Z. Abbas. 2016. Hypoglycemic and hypolipidemic effects of *Lactobacillus fermentum*, fruit extracts of *Syzygium cumini* and *Momordica charantia* on diabetes induced mice. *Pakistan journal of pharmaceutical sciences* 29:(5), 1535-1540. **0.7**
14. Husain, A. **S. U. Rehman**, S. Aslam, N. Javed, and Z. Abbas. 2014. Nano-Gold Particles Mediated Detection of NS1; An Early Diagnostic Marker of Dengue Virus Infection. *The Journal of Animal & Plant Sciences* **24**:1110-1115. <http://www.thejaps.org.pk/docs/v-24-4/21.pdf> **0.7**
15. Raza, F. A., **S. U. Rehman**, R. Khalid, J. Ahmad, S. Ashraf, M. Iqbal, and S. Hasnain. 2014. Demographic and clinico-epidemiological features of dengue Fever in faisalabad, pakistan. *PLoS One* **9**:e89868. <https://doi.org/10.1371/journal.pone.0089868>. **3.5**
16. Brown, R. J., N. Hudson, G. Wilson, **S. U. Rehman**, S. Jabbari, K. Hu, A. W. Tarr, P. Borrow, M. Joyce, J. Lewis, L. F. Zhu, M. Law, N. Kneteman, D. L. Tyrrell, J. A. McKeating, and J. K. Ball. 2012. Hepatitis C virus envelope glycoprotein fitness defines virus population composition following transmission to a new host. *Journal of virology* **86**:11956-11966. <https://doi.org/10.1128/JVI.01079-12>. **5.0**

REFERENCE

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