UNIVERSITI PUTRA MALAYSIA

MOLECULAR IDENTIFICATION OF DENGUE VIRUS BINDING PROTEIN ON FILOPODIA OF VERO CELLS

ISAH ABUBAKAR ALIYU

FPSK(p) 2019 10

MOLECULAR IDENTIFICATION OF DENGUE VIRUS BINDING PROTEIN ON FILOPODIA OF VERO CELLS

By

ISAH ABUBAKAR ALIYU

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

May 2017

DEDICATION

This thesis was dedicated to my lovely father Alh. Abubakar Aliyu who passed away few weeks to the completion of this write-up (on 11th January 2017). May ALLAH (Subhanahu wata'ala) forgive his sins and make Jannatul Firdausi his final abode Amin.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

MOLECULAR IDENTIFICATION OF DENGUE VIRUS BINDING PROTEIN ON FILOPODIA OF VERO CELL

By

ISAH ABUBAKAR ALIYU

May 2017

Chair : Associate Professor Chee Hui Yee, PhD
Faculty : Medicine and Health Sciences

Despite much efforts to control dengue virus, there is still neither scientifically proven effective drug nor an effective internationally licensed vaccine to treat or control dengue. Recent evidence has demonstrated that dengue virus requires an active filopodia formation for successful infection. However, the precise mechanism for dengue virus interaction with filopodia to enhance virus infection is not fully understood. Therefore, the present study was designed to identify the dengue virus 2 binding protein that could be responsible for enhanced virus infection upon filopodia formation. Filopodia formation in Vero cells was induced with bradykinin and a combination of virus overlay protein binding assay (VOPBA) and LC-MS/MS was employed to identify annexin II as a dengue virus 2 binding protein on filopodia-induced cells. Translocation of annexin II to the external leaflet of plasma membrane following filopodia formation was demonstrated by immunocytochemistry staining and western blotting analysis. Down-regulation of plasma membrane annexin II was observed in response to dengue virus 2 infection. Moreover, anti-annexin II antibody inhibited virus binding in an antibody-dependent binding inhibition assay and a dose-dependent reduction in both dengue virus infection level and virus production was demonstrated in an antibody-mediated infection inhibition assay. Similarly, siRNA-mediated knockdown of annexin II gene significantly reduced virus infection level as well as virus production. Confocal microscopic examination showed extracellular and intracellular colocalization between annexin II and dengue virus 2 E glycoprotein, and co-immunoprecipitation assay confirmed that annexin II interacted with dengue virus 2 E glycoprotein. Furthermore, the putative annexin II interaction site on dengue virus 2 E glycoprotein was predicted using molecular docking and the interaction was likely to occur at residues Ile-380 to Leu-389 of E glycoprotein, with Ser-22 to Asn-32, Leu-300 to Tyr-317 and Lys-328 to Asp-338 of annexin II. Data from the present study reported for the first time the expression of a dengue virus 2 binding protein upon filopodia formation, which might be involved in dengue virus 2 binding, internalization and intracellular trafficking. Thus, the results could explain the likely reason behind enhanced virus infection observed upon filopodia formation and could be a potential target for the development of a novel antiviral.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

IDENTIFIKASI PROTEIN PENGIKAT VIRUS DENGGI DENGAN FILOPODIA DALAM SEL VIRO PADA PERIGKAT MOLEKULAR

Oleh

ISAH ABUBAKAR ALIYU

Mei 2017

Pengerusi : Profesor Madya Chee Hui Yee, PhD
Fakulti : Perubatan dan Sains Kesihatan

Walaupun pelbagai usaha telah diambil untuk mengawal virus denggi, namun masih tiada pembuktian secara saintifik ubat yang berkesan mahupun vaksin yang dilesenkan secara meluas untuk merawat atau mengawal denggi. Kajian terkini telah menunjukkan bahawa virus denggi memerlukan pembentukan filopodia yang aktif untuk sesuatu jangkitan itu berjaya. Walau bagaimanapun, mekanisma interaksi antara virus denggi dengan filopodia yang mengakibatkan peningkatan infeksi masih belum difahami sepenuhnya. Oleh itu, kajian ini adalah bertujuan untuk mengenal pasti protin pengikat virus denggi serotaip 2 yang mungkin bertanggungjawab dalam peningkatan infeksi berikutan pembentukan filopodia. Dalam kajian ini, kombinasi penggunaan teknik Virus Overlay Protein Binding Assay (VOPBA) dengan LC-MS/MS telah mengenalpasti annexin II sebagai protin pengikat virus denggi serotaip 2 dalam sel-sel Vero yang telah dirangsangkan pembentukan filopodia oleh bradykinin. Translokasi annexin II ke permukaan luaran membran plasma selepas pembentukan filopodia juga dapat diperhatikan dengan menggunakan pewarnaan immunositokimia dan pedapan Western. Sementara itu, ekspresi annexin II di permukaan membran plasma didapati menurun berikutan infeksi virus denggi serotaip 2. Antibodi anti-annexin II didapati merencatkan pengikatan virus dalam ujian perencatan pengikatan di mana jangkitan serta penghasilan virus denggi berkurang bersandarkan dos antibodi. Manakala, penggunaan siRNA yang boleh merencatkan pengekspresan gen annexin II juga didapati mengurangkan tahap jangkitan serta penghasilan virus secara ketara. Pemeriksaan mikroskopi konfokal menunjukkan persetempatan annexin II dengan protin E virus denggi serotaip 2 di luaran dan di dalaman sel. Selanjutnya, ujian pemendakan ko-immuno telah mengesahkan bahawa annexin II sememangnya berinteraksi dengan protin E virus denggi serotaip 2. Melalui program dok molekul, lokasi interaksi annexin II dengan protin E virus denggi serotaip 2 telah diramalkan berlaku pada lokasi Ile380 hingga Leu389 pada protin E dengan Ser-22 hingga Asn-32, Leu-300 hingga Tyr-317 dan Lys-328 hingga Asp-338 pada annexin II. Buat kali pertamanya kajian ini telah mengenalpasti pengekspresan protin pengikat virus denggi serotaip 2 berikutan pembentukan filopodia yang mungkin terlibat dalam pengikatan, internalisasi dan pengedaran selular virus denggi serotaip 2. Oleh itu, hasil kajian ini dapat menerang sebab peningkatan infeksi virus yang diperhatikan berikutan pembentukan filopodia dan ini boleh dijadikan sebagai sasaran yang berpotensi untuk pencarian antiviral yang novel.

ACKNOWLEDGEMENTS

All praise, thanks, and salutation are due to almighty ALLAH, the creator of seven heaven and seven earth, the sustainer, the only super power of an unimaginable magnitude, for which mankind and creation cannot fully comprehend, the beneficent, the merciful with whose mercy I have accomplished this study. May the peace and blessing of ALLAH be upon his noblest messenger Muhammad (PBUH), his households, his companion and all those who follows his path till the day of reckoning. And after that;

My sincere gratitude goes to my main supervisor Dr. Chee Hui Yee. Who demonstrated extra patients and enthusiasm in guiding and supporting me during my research and the write-up. It is a lot of experience working in her laboratory, she had extensively devoted me to reason and act scientifically. And despite her tight schedules, she generously guided and supported me throughout the period of my PhD journey. The weekly progress presentation and the review of the most current article has really shaped and grown me experimentally and scientifically beyond what I previously thought. My thanks and appreciation can never be overemphasized. My special thanks and appreciation also go to my co-supervisors Dr. Nur Fariesha Md Hashim and Dr. Ling King Hwa. They are always very helpful, without their guidance and advice this thesis wouldn't have been successful. And to all the lecturers and staff members of the Faculty of Medicine and Health Sciences, University Putra Malaysia (UPM).

My heart-breaking appreciation and prayer are due to my Dad who passed away few weeks to the completion of this thesis writ-up. My prayer will always be for ALLAH to forgive all your sins and may HE make Jannatul Firdause your final abode Amin. And to my beloved mum, for her unrelenting support, encouragement, assistance and guidance throughout the duration of my study. May ALLAH reward both of them with Jannatul Firdaus, Amin.

My humble appreciation is due to my lovely wife, who really assisted me morally and physically, and take good care of me and our kids, while I was busy with the laboratory experiment. Your patients were really appreciated for all the times I had to stay late night in the laboratory. And to our lovely kids Khadija, Fatima and Ahmad they always pray for me and encourage me, may ALLAH bless your life Amin.

I also owed special appreciation to the management of Bayero University Kano (BUK) for giving me the opportunity to pursue my PhD training, without their commitment this study wouldn't have been possible. And to the entire staff members of the department of Medical Laboratory Science BUK, especially the head of the department Dr. Abdulhadi S.K., who visited me here in Malaysia to show support and encouragement. May ALLAH reward you abundantly Amin. And to my colleague, friend and brother, Jamilu A.B., for brotherly assistance rendered to me during my PhD journey.

Finally, I want to express my warmest appreciation to all my laboratory mates, for their collaborative assistance. And laboratory staffs, I am specifically grateful to staffs of the

institute of bioscience UPM microscopy section, for their invaluable assistance and cooperation demonstrated to me during my study. And to my colleagues from Medical Genetic Laboratory and pharmacotherapeutics Laboratory UPM. A special thanks to Dr Dahiru S., for his assistance in typesetting of this thesis. I am also grateful to all my friends and well-wishers who in one way or the other contributed toward accomplishment of my study. Thank you all.

I certify that a Thesis Examination Committee has met on 15 May 2017 to conduct the final examination of Isah Abubakar Aliyu on his thesis entitled "Molecular identification of dengue virus binding protein on filopodia of vero cells" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the (insert the name of relevant degree).

Members of the Thesis Examination Committee were as follows:

Zamberi bin Sekawi, PhD
Professor
Faculty of Medicine and Health sciences
Universiti Putra Malaysia
(Chairman)

Abdul Rahman Omar, PhD
Title (e.g., Professor/Associate Professor/Ir; omit if irrelevant)
Name of Faculty
Universiti Putra Malaysia
(Internal Examiner)

Fong Mun Yik, PhD
Professor
Faculty of Medicine
University of Malaya
(External Examiner)

Yi-Ling Lin, PhD
Associate Professor
Institute of Biomedical Sciences
Academia Sinica, Taipei
Taiwan
(External Examiner)

_____
RUSLI HAJI ABDULLAH, PhD)
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

Chee Hui Yee, PhD
Associate Professor
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Chairman)

Nur Fariesha Binti Md Hashim, PhD
Senior Lecturer
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Member)

Ling King Hwa (Michael), PhD
Senior Lecturer
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Member)

_____
ROBIAH BINTI YUNUS, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and Innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.

Signature: _____ Date: _____

Name and Matric No.: Isah Abubakar Aliyu, GS41465

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature: _____
Name of Chairman of Supervisory Committee: Associate Professor Chee Hui Yee

Signature: _____
Name of Member of Supervisory Committee: Dr. Nur Fariesha Md Hashim

Signature: _____
Name of Member of Supervisory Committee: Dr. Ling King Hwa

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ARP2/3	Actin-related protein 2/3
BHK	Baby hamster kidney cell line
C protein	Core protein
CD4	Cluster of differentiation 4
CMV	Cytomegalovirus
CPE	Cytopathic effect
DAPI	4',6-diamidino-2-phenylindole
DC-SING	Dendritic cell-specific intercellular adhesion molecule 3-grabbing nonintegrin
DHF	Dengue hemorrhagic fever
Dia2	Diaphanous-related formin-2
DMSO	Dimethyl sulfoxide
DSS	Dengue shock syndrome
E glycoprotein	Envelope glycoprotein
EMEM	Eagles minimal essential media
ENA/VASP	Enabled/vasodilator-stimulated phosphoprotein
FBS	Foetal bovine serum
FITC	Fluorescence isothiocynate
HCV	Hepatitis C virus
HPV	Human papillomavirus
LC-MS/MS	Liquid chromatography- mass spectrophotometry/mass spectrophotometry
M/prM protein	Membrane protein, and precursor protein pr

MENA	Mammalian enabled
NSP	Non-structural protein
PI	Post infection
PT	Post transfection
PVDF	Polyvinylidene fluoride
SDS-PAGE	Sodium dodecyl sulfate polyacrylamide gel electrophoresis
SiRNA	Small interference RNA
TCID50	Tissue culture infectious dose 50
VOPBA	Virus overlay protein binding assay
WASP	Wiskott-Aldrich syndrome protein
WAVE2	(WASP) family verprolin-homologous protein 2

CHAPTER 1

INTRODUCTION

1.1 Background of the studies

Dengue virus is the most widespread mosquito-borne virus infection with immense global health importance. It is an etiologic agent of a mild fever known as dengue fever, or a more severe dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS). The disease is ubiquitous in tropical and subtropical countries especially in Asia and Latin America, it is albeit endemic in more than 100 countries (Ligon, 2005). Dengue virus global prevalence was estimated using cartographic modelling to be 390 million cases annually, with about 96 million cases requiring hospitalization, and more than 200,000 annual mortality rates, 22,000 of which is among minor (Bhatt et al., 2013a; Pang and Loh, 2016; Rigau-Pérez et al., 1998).

Despite the prominence and growing incidence of dengue virus infection, there is no specific antiviral agents or widely accepted licensed vaccines available for prevention or treatment of dengue virus infection. Generally, viral enzyme targeted drugs are used to treat viral infections, however the main problem in the use of these types of drugs is the emergence of resistance (Kieffer and George, 2014; Pennings, 2012; van der Vries et al., 2013). Research for dengue virus vaccines has been hampered by many factors including antibody-dependent enhancement of infection, original antigenic sin hypothesis and poor immunogenicity of subunits vaccines. Because of these factors, antiviral drug discovery has been tilted toward the possibility of developing host-oriented molecules that act on the cellular functions which are essential for virus entry and replication (de Chassey et al., 2014). This therapeutic strategy has successfully been used with promising result and has been approved for clinical use in HIV infection (Haqqani and Tilton, 2013).

Viral entry-associated proteins on the surface of target cells are important basic information for designing prevention and treatment strategies for viral diseases. Hence there is need to employ this therapeutic strategy in dengue virus by targeting virus binding molecules on susceptible host cells. Blockage of this molecules will prevent virus binding, entry and establishment of infection. However, to date, there is no detailed information on dengue virus interacting molecule which is indispensable for dengue virus attachment, trafficking, and internalization. This makes it difficult or almost impossible to address dengue virus entry-associated proteins for the development of dengue virus therapeutic.

Many studies have been carried out to identify molecules involved in the dengue virus host interaction. Independent studies showed that different proteins, including high-affinity laminin receptor (Thepparit and Smith, 2004; Tio et al., 2005), CD14-associated protein (Chen et al., 1997), and uncharacterized proteins (de Jesús Martínez-Barragán and del Angel, 2001) may be involved in dengue virus-host cell interaction, detailed of these molecules have been reviewed by Cruz-Oliveira et al. (2014). However, it has been

reported therein, that these molecules were not involved in dengue virus high-affinity interaction and internalization.

A possible candidate route for dengue virus entry into the host cell via interaction with cellular protrusion like filopodia has also been reported. Viruses have been observed to induce cytoskeletal rearrangement, which is associated with cellular signals that lead to the formation of filopodia (Smith et al., 2008). This is seen to be crucial in viral infection. After virus attachment, filopodia has been reported to play an important role in the virus confinement to the plasma membrane for internalization (Ewers et al., 2005; Pelkmans et al., 2002). Dengue virus was also reported to induce filopodia formation on host cells for successful infection (Zamudio-Meza et al., 2009). However, the molecular mechanism and protein interaction associated with virus-filopodia interaction has never been investigated. Hence, this research was designed to investigate the molecular mechanism and to identify dengue virus 2 interacting protein on filopodia of host cells involved in virus binding, trafficking, and internalization. It has been hypothesized in the present study that filopodia formation results in the expression of key molecules on the cells which are important for dengue virus interaction and internalization.

1.2 Objectives

The main objective of this study is to identify dengue virus 2 binding proteins on filopodia.

Specific objectives were to:

i. chemically induce filopodia formation, investigate and identify dengue virus 2 binding protein in plasma membrane fraction of filopodia-induced cells.

ii. determine the expression of this dengue virus 2 binding protein in filopodia-induced cells, and whether the expression of this protein is altered in response to dengue virus 2 infection

iii. determine whether this dengue virus 2 binding protein plays a receptor role in dengue virus 2 infection

iv. investigate and determine intracellular interaction between this protein and dengue virus 2 E glycoprotein.

REFERENCES

Acosta, E.G., Castilla, V., Damonte, E.B., 2008. Functional entry of dengue virus into Aedes albopictus mosquito cells is dependent on clathrin-mediated endocytosis. Journal of General Virology 89, 474-484.

Aoki, C., Hidari, K.I., Itonori, S., Yamada, A., Takahashi, N., Kasama, T., Hasebe, F., Islam, M.A., Hatano, K., Matsuoka, K., 2006. Identification and characterization of carbohydrate molecules in mammalian cells recognized by dengue virus type 2. Journal of Biochemistry 139, 607-614.

Apodaca, G., 2001. Endocytic traffic in polarized epithelial cells: role of the actin and microtubule cytoskeleton. Traffic 2, 149-159.

Applewhite, D.A., Barzik, M., Kojima, S.-i., Svitkina, T.M., Gertler, F.B., Borisy, G.G., 2007. Ena/VASP proteins have an anti-capping independent function in filopodia formation. Molecular Biology of the Cell 18, 2579-2591.

Aratyn, Y.S., Schaus, T.E., Taylor, E.W., Borisy, G.G., 2007. Intrinsic dynamic behavior of fascin in filopodia. Molecular Biology of the Cell 18, 3928-3940.

Babbin, B.A., Parkos, C.A., Mandell, K.J., Winfree, L.M., Laur, O., Ivanov, A.I., Nusrat, A., 2007. Annexin 2 regulates intestinal epithelial cell spreading and wound closure through Rho-related signaling. The American Journal of Pathology 170, 951-966.

Backes, P., Quinkert, D., Reiss, S., Binder, M., Zayas, M., Rescher, U., Gerke, V., Bartenschlager, R., Lohmann, V., 2010. Role of annexin A2 in the production of infectious hepatitis C virus particles. Journal of Virology 84, 5775-5789.

Bartenschlager, R., Sparacio, S., 2007. Hepatitis C virus molecular clones and their replication capacity in vivo and in cell culture. Virus Research 127, 195-207.

Barzik, M., Kotova, T.I., Higgs, H.N., Hazelwood, L., Hanein, D., Gertler, F.B., Schafer, D.A., 2005. Ena/VASP proteins enhance actin polymerization in the presence of barbed end capping proteins. Journal of Biological Chemistry 280, 28653-28662.

Bear, J.E., Gertler, F.B., 2009. Ena/VASP: towards resolving a pointed controversy at the barbed end. Journal Cell Science 122, 1947-1953.

Bellagamba, C., Hubaishy, I., Bjorge, J.D., Fitzpatrick, S.L., Fujita, D.J., Waisman, D.M., 1997. Tyrosine phosphorylation of annexin II tetramer is stimulated by membrane binding. Journal of Biological Chemistry 272, 3195-3199.

Berg, J.S., Cheney, R.E., 2002. Myosin-X is an unconventional myosin that undergoes intrafilopodial motility. Nature Cell Biology 4, 246-250.

Berg, J.S., Derfler, B.H., Pennisi, C.M., Corey, D.P., Cheney, R.E., 2000. Myosin-X, a novel myosin with pleckstrin homology domains, associates with regions of dynamic actin. Journal of Cell Science 113, 3439-3451.

Bhatt, S., Gething, P.W., Brady, O.J., Messina, J.P., Farlow, A.W., Moyes, C.L., Drake, J.M., Brownstein, J.S., Hoen, A.G., Sankoh, O., 2013a. The global distribution and burden of dengue. Nature 496, 504-507.

Bhatt, S., Gething, P.W., Brady, O.J., Messina, J.P., Farlow, A.W., Moyes, C.L., Drake, J.M., Brownstein, J.S., Hoen, A.G., Sankoh, O., Myers, M.F., George, D.B., Jaenisch, T., Wint, G.R.W., Simmons, C.P., Scott, T.W., Farrar, J.J., Hay, S.I., 2013b. The global distribution and burden of dengue. Nature 496, 504-507.

Bielefeldt-Ohmann, H., 1998. Analysis of antibody-independent binding of dengue viruses and dengue virus envelope protein to human myelomonocytic cells and B lymphocytes. Virus Research 57, 63-79.

Bielefeldt-Ohmann, H., Meyer, M., Fitzpatrick, D.R., Mackenzie, J.S., 2001. Dengue virus binding to human leukocyte cell lines: receptor usage differs between cell types and virus strains. Virus Research 73, 81-89.

Böttcher, E., Matrosovich, T., Beyerle, M., Klenk, H.-D., Garten, W., Matrosovich, M., 2006. Proteolytic activation of influenza viruses by serine proteases TMPRSS2 and HAT from human airway epithelium. Journal of Virology 80, 9896-9898.

Boudreau, N., Jones, P., 1999. Extracellular matrix and integrin signalling: the shape of things to come. Biochemistry Journal 339, 481-488.

Bradford, M.M., 1976. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. Analytical Biochemistry 72, 248-254.

Breiner, K.M., Urban, S., Glass, B., Schaller, H., 2001. Envelope protein-mediated down-regulation of hepatitis B virus receptor in infected hepatocytes. Journal of Virology 75, 143-150.

Bringans, S., Eriksen, S., Kendrick, T., Gopalakrishnakone, P., Livk, A., Lock, R., Lipscombe, R., 2008. Proteomic analysis of the venom of Heterometrus longimanus (Asian black scorpion). Proteomics 8, 1081-1096.

Burdon, R.H., 1993. Heat shock proteins in relation to medicine. Molecular Aspects of Medicine 14, 83-165.

Cabrera-Hernandez, A., Thepparit, C., Suksanpaisan, L., Smith, D.R., 2007. Dengue virus entry into liver (HepG2) cells is independent of hsp90 and hsp70. Journal of Medical Virology 79, 386-392.

Capeding, M.R., Tran, N.H., Hadinegoro, S.R.S., Ismail, H.I.H.M., Chotpitayasunondh, T., Chua, M.N., Luong, C.Q., Rusmil, K., Wirawan, D.N., Nallusamy, R., 2014. Clinical efficacy and safety of a novel tetravalent dengue vaccine in healthy

children in Asia: a phase 3, randomised, observer-masked, placebo-controlled trial. The Lancet 384, 1358-1365.

Caplan, J.F., Filipenko, N.R., Fitzpatrick, S.L., Waisman, D.M., 2004. Regulation of annexin A2 by reversible glutathionylation. Journal of Biological Chemistry 279, 7740-7750.

Caron, D., Boutchueng-Djidjou, M., Tanguay, R.M., Faure, R.L., 2015. Annexin A2 is SUMOylated on its N-terminal domain: Regulation by insulin. FEBS Letters 589, 985-991.

Castilla, V., Piccini, L.E., Damonte, E.B., 2015. Dengue virus entry and trafficking: perspectives as antiviral target for prevention and therapy. Future Virology 10, 625-645.

Chang, K., Baginski, J., Hassan, S.F., Volin, M., Shukla, D., Tiwari, V., 2016. Filopodia and viruses: an analysis of membrane processes in entry mechanisms. Frontiers in Microbiology 7.

Che, P., Tang, H., Li, Q., 2013. The interaction between claudin-1 and dengue viral prM/M protein for its entry. Virology 446, 303-313.

Cheah, W., Ng, K., Marzilawati, A., Lum, L., 2014. A review of dengue research in malaysia. The Medical Journal of Malaysia 69, 59-67.

Chee, H.-Y., AbuBakar, S., 2004. Identification of a 48kDa tubulin or tubulin-like C6/36 mosquito cells protein that binds dengue virus 2 using mass spectrometry. Biochemical and Biophysical Research Communications 320, 11-17.

Chen, Y.-C., Wang, S.-Y., King, C.-C., 1999. Bacterial lipopolysaccharide inhibits dengue virus infection of primary human monocytes/macrophages by blockade of virus entry via a CD14-dependent mechanism. Journal of Virology 73, 2650-2657.

Chen, Y., Maguire, T., Hileman, R.E., Fromm, J.R., Esko, J.D., Linhardt, R.J., Marks, R.M., 1997. Dengue virus infectivity depends on envelope protein binding to target cell heparan sulfate. Nature Medicine 3, 866-871.

Chertova, E., Chertov, O., Coren, L.V., Roser, J.D., Trubey, C.M., Bess, J.W., Sowder, R.C., Barsov, E., Hood, B.L., Fisher, R.J., 2006. Proteomic and biochemical analysis of purified human immunodeficiency virus type 1 produced from infected monocyte-derived macrophages. Journal of Virology 80, 9039-9052.

Chhabra, E.S., Higgs, H.N., 2007. The many faces of actin: matching assembly factors with cellular structures. Nature Cell Biology 9, 1110-1121.

Chu, J., Leong, P., Ng, M., 2006. Analysis of the endocytic pathway mediating the infectious entry of mosquito-borne flavivirus West Nile into Aedes albopictus mosquito (C6/36) cells. Virology 349, 463-475.

Chu, J., Yang, P.L., 2007. c-Src protein kinase inhibitors block assembly and maturation of dengue virus. Proceedings of the National Academy of Sciences 104, 3520-3525.

Coyne, C.B., Bergelson, J.M., 2006. Virus-induced Abl and Fyn kinase signals permit coxsackievirus entry through epithelial tight junctions. Cell 124, 119-131.

Creutz, C., Zaks, W., Hamman, H., Crane, S., Martin, W., Gould, K., Oddie, K., Parsons, S., 1987. Identification of chromaffin granule-binding proteins. Relationship of the chromobindins to calelectrin, synhibin, and the tyrosine kinase substrates p35 and p36. Journal of Biological Chemistry 262, 1860-1868.

Creutz, C.E., Pazoles, C.J., Pollard, H.B., 1978. Identification and purification of an adrenal medullary protein (synexin) that causes calcium-dependent aggregation of isolated chromaffin granules. Journal of Biological Chemistry 253, 2858-2866.

Crill, W.D., Roehrig, J.T., 2001. Monoclonal antibodies that bind to domain III of dengue virus E glycoprotein are the most efficient blockers of virus adsorption to Vero cells. Journal of Virology 75, 7769-7773.

Crumpton, M., 1990. Protein terminology tangle. Nature 345, 212.

Cruz-Oliveira, C., Freire, J.M., Conceição, T.M., Higa, L.M., Castanho, M.A., Da Poian, A.T., 2014. Receptors and routes of dengue virus entry into the host cells. FEMS Microbiology Reviews, fuu004.

Csermely, P., Schnaider, T., So, C., Prohászka, Z., Nardai, G., 1998. The 90-kDa molecular chaperone family: structure, function, and clinical applications. A comprehensive review. Pharmacology & Therapeutics 79, 129-168.

Dalrymple, N., Mackow, E.R., 2011. Productive dengue virus infection of human endothelial cells is directed by heparan sulfate-containing proteoglycan receptors. Journal of Virology 85, 9478-9485.

de Chassey, B., Meyniel-Schicklin, L., Vonderscher, J., André, P., Lotteau, V., 2014. Virus-host interactomics: new insights and opportunities for antiviral drug discovery. Genome Medicine 6, 1.

de Haan, C.A., Li, Z., te Lintelo, E., Bosch, B.J., Haijema, B.J., Rottier, P.J., 2005. Murine coronavirus with an extended host range uses heparan sulfate as an entry receptor. Journal of virology 79, 14451-14456.

de Jesús Martínez-Barragán, J., del Angel, R.M., 2001. Identification of a putative coreceptor on Vero cells that participates in dengue 4 virus infection. Journal of Virology 75, 7818-7827.

de Wispelaere, M., LaCroix, A.J., Yang, P.L., 2013. The small molecules AZD0530 and dasatinib inhibit dengue virus RNA replication via Fyn kinase. Journal of Virology 87, 7367-7381.

Deora, A.B., Kreitzer, G., Jacovina, A.T., Hajjar, K.A., 2004. An annexin 2 phosphorylation switch mediates p11-dependent translocation of annexin 2 to the cell surface. Journal of Biological Chemistry 279, 43411-43418.

Derry, M.C., Sutherland, M.R., Restall, C.M., Waisman, D.M., Pryzdial, E.L., 2007. Annexin 2-mediated enhancement of cytomegalovirus infection opposes inhibition by annexin 1 or annexin 5. Journal of General Virology 88, 19-27.

Drücker, P., Pejic, M., Galla, H.-J., Gerke, V., 2013. Lipid segregation and membrane budding induced by the peripheral membrane binding protein annexin A2. Journal of Biological Chemistry 288, 24764-24776.

Dziduszko, A., Ozbun, M.A., 2013. Annexin A2 and S100A10 regulate human papillomavirus type 16 entry and intracellular trafficking in human keratinocytes. Journal of Virology 87, 7502-7515.

Eash, S., Atwood, W.J., 2005. Involvement of cytoskeletal components in BK virus infectious entry. Journal of Virology 79, 11734-11741.

Eberhard, D.A., Karns, L.R., VandenBerg, S.R., Creutz, C.E., 2001. Control of the nuclear-cytoplasmic partitioning of annexin II by a nuclear export signal and by p11 binding. Journal of Cell Science 114, 3155-3166.

Erikson, E., Erikson, R., 1980. Identification of a cellular protein substrate phosphorylated by the avian sarcoma virus-transforming gene product. Cell 21, 829-836.

Esclatine, A., Bellon, A., Michelson, S., Servin, A.L., Quéro, A.-M., Géniteau-Legendre, M., 2001. Differentiation-dependent redistribution of heparan sulfate in epithelial intestinal Caco-2 cells leads to basolateral entry of cytomegalovirus. Virology 289, 23-33.

Etienne-Manneville, S., Hall, A., 2002. Rho GTPases in cell biology. Nature 420, 629-635.

Ewers, H., Smith, A.E., Sbalzarini, I.F., Lilie, H., Koumoutsakos, P., Helenius, A., 2005. Single-particle tracking of murine polyoma virus-like particles on live cells and artificial membranes. Proceedings of the National Academy of Sciences of the United States of America 102, 15110-15115.

Faix, J., Grosse, R., 2006. Staying in shape with formins. Developmental Cell 10, 693-706.

Faix, J., Rottner, K., 2006. The making of filopodia. Current Opinion in Cell Biology 18, 18-25.

Fang, Y.T., Lin, C.F., Wang, C.Y., Anderson, R., Lin, Y.S., 2012. Interferon-γ stimulates p11-dependent surface expression of annexin A2 in lung epithelial cells to enhance phagocytosis. Journal of Cellular Physiology 227, 2775-2787.

Fibriansah, G., Ng, T.-S., Kostyuchenko, V.A., Lee, J., Lee, S., Wang, J., Lok, S.-M., 2013. Structural changes in dengue virus when exposed to a temperature of 37 C. Journal of Virology 87, 7585-7592.

Flower, R., 1986. Background and discovery of lipocortins. Inflammation Research 17, 255-262.

Fongsaran, C., Jirakanwisal, K., Kuadkitkan, A., Wikan, N., Wintachai, P., Thepparit, C., Ubol, S., Phaonakrop, N., Roytrakul, S., Smith, D.R., 2014. Involvement of ATP synthase β subunit in chikungunya virus entry into insect cells. Archives of Virology 159, 3353-3364.

Freire, J.M., Veiga, A.S., Conceição, T.M., Kowalczyk, W., Mohana-Borges, R., Andreu, D., Santos, N.C., Da Poian, A.T., Castanho, M.A., 2013. Intracellular nucleic acid delivery by the supercharged dengue virus capsid protein. PloS one 8, e81450.

Futter, C.E., White, I.J., 2007. Annexins and endocytosis. Traffic 8, 951-958.

Gallagher, J., Lyon, M., 2000. Molecular structure of heparan sulfate and interactions with growth factors and morphogens. Proteoglycans: Structure, Biology and Molecular Interactions, 27-59.

Gao, L., Aizaki, H., He, J.-W., Lai, M.M., 2004. Interactions between viral nonstructural proteins and host protein hVAP-33 mediate the formation of hepatitis C virus RNA replication complex on lipid raft. Journal of Virology 78, 3480-3488.

Ge, P., Zhou, Z.H., 2014. Chaperone fusion proteins aid entropy-driven maturation of class II viral fusion proteins. Trends in Microbiology 22, 100-106.

Gerke, V., Creutz, C.E., Moss, S.E., 2005. Annexins: linking Ca2+ signalling to membrane dynamics. Nature Reviews Molecular Cell Biology 6, 449-461.

Gerke, V., Moss, S.E., 1997. Annexins and membrane dynamics. Biochimica et Biophysica Acta (BBA)-Molecular Cell Research 1357, 129-154.

Gerke, V., Moss, S.E., 2002. Annexins: from structure to function. Physiological Reviews 82, 331-371.

Gerke, V., Weber, K., 1985. Calcium-dependent conformational changes in the 36-kDa subunit of intestinal protein I related to the cellular 36-kDa target of Rous sarcoma virus tyrosine kinase. Journal of Biological Chemistry 260, 1688-1695.

Germi, R., Crance, J.-M., Garin, D., Guimet, J., Lortat-Jacob, H., Ruigrok, R.W., Zarski, J.-P., Drouet, E., 2002. Heparan sulfate-mediated binding of infectious dengue virus type 2 and yellow fever virus. Virology 292, 162-168.

Ghezzi, P., 2013. Protein glutathionylation in health and disease. Biochimica et Biophysica Acta (BBA)-General Subjects 1830, 3165-3172.

Ghitescu, L.D., Gugliucci, A., Dumas, F., 2001. Actin and annexins I and II are among the main endothelial plasmalemma-associated proteins forming early glucose adducts in experimental diabetes. Diabetes 50, 1666-1674.

Glenney, J.R., Tack, B.F., 1985. Amino-terminal sequence of p36 and associated p10: identification of the site of tyrosine phosphorylation and homology with S-100. Proceedings of the National Academy of Sciences 82, 7884-7888.

Gokhale, N.A., Abraham, A., Digman, M.A., Gratton, E., Cho, W., 2005. Phosphoinositide specificity of and mechanism of lipid domain formation by annexin A2-p11 heterotetramer. Journal of Biological Chemistry 280, 42831-42840.

Gong, G., Waris, G., Tanveer, R., Siddiqui, A., 2001. Human hepatitis C virus NS5A protein alters intracellular calcium levels, induces oxidative stress, and activates STAT-3 and NF-κB. Proceedings of the National Academy of Sciences 98, 9599-9604.

Goode, B.L., Eck, M.J., 2007. Mechanism and function of formins in the control of actin assembly. Annual Review of Biochemistry. 76, 593-627.

Gould, K., Woodgett, J., Isacke, C., Hunter, T., 1986. The protein-tyrosine kinase substrate p36 is also a substrate for protein kinase C in vitro and in vivo. Molecular and Cellular Biology 6, 2738-2744.

Grieve, A.G., Moss, S.E., Hayes, M.J., 2012. Annexin A2 at the interface of actin and membrane dynamics: a focus on its roles in endocytosis and cell polarization. International Journal of Cell Biology 2012.

Grindheim, A.K., Hollås, H., Raddum, A.M., Saraste, J., Vedeler, A., 2016. Reactive oxygen species exert opposite effects on Tyr23 phosphorylation of the nuclear and cortical pools of annexin A2. Journal of Cell Science 129, 314-328.

Grove, J., Marsh, M., 2011. The cell biology of receptor-mediated virus entry. The Journal of Cell Biology 195, 1071-1082.

Gubler, D.J., 1998. Dengue and dengue hemorrhagic fever. Clinical Microbiology Reviews 11, 480-496.

Gupton, S.L., Gertler, F.B., 2007. Filopodia: the fingers that do the walking. Science Signaling 2007, re5.

Hajjar, K.A., Jacovina, A.T., Chacko, J., 1994. An endothelial cell receptor for plasminogen/tissue plasminogen activator. I. Identity with annexin II. Journal of Biological Chemistry 269, 21191-21197.

Hajjar, K.A., Krishnan, S., 1999. Annexin II: a mediator of the plasmin/plasminogen activator system. Trends in Cardiovascular Medicine 9, 128-138.

Hall, A., 1998. Rho GTPases and the actin cytoskeleton. Science 279, 509-514.

Halstead, S.B., 2002. Dengue. Current Opinion in Infectious Diseases 15, 471-476.

Halstead, S.B., 2003. Neutralization and antibody-dependent enhancement of dengue viruses. Advances in Virus Research 60, 421-467.

Halstead, S.B., 2007. Dengue. The Lancet 370, 1644-1652.

Haqqani, A.A., Tilton, J.C., 2013. Entry inhibitors and their use in the treatment of HIV-1 infection. Antiviral Research 98, 158-170.

Harburger, D.S., Calderwood, D.A., 2009. Integrin signalling at a glance. Journal of Cell Science 122, 159-163.

Hay, R.T., 2005. SUMO: a history of modification. Molecular Cell 18, 1-12.

Hayes, M.J., Rescher, U., Gerke, V., Moss, S.E., 2004. Annexin–actin interactions. Traffic 5, 571-576.

Hayes, M.J., Shao, D., Bailly, M., Moss, S.E., 2006. Regulation of actin dynamics by annexin 2. The EMBO Journal 25, 1816-1826.

Hendriks, I.A., Vertegaal, A.C., 2016a. A comprehensive compilation of SUMO proteomics. Nature Reviews Molecular Cell Biology 17, 581-595.

Hendriks, I.A., Vertegaal, A.C., 2016b. A high-yield double-purification proteomics strategy for the identification of SUMO sites. Nature Protocols 11, 1630-1649.

Hidari, K.I., Suzuki, T., 2011. Dengue virus receptor. Tropical Medicine and Health 39, S37-S43.

Hierholzer, J., Killington, R., 1996. Virus isolation and quantitation. Virology Methods Manual, 25-46.

Higa, Y., 2011. Dengue vectors and their spatial distribution. Tropical Medicine and Health 39, S17-S27.

Hilgard, P., Stockert, R., 2000. Heparan sulfate proteoglycans initiate dengue virus infection of hepatocytes. Hepatology 32, 1069-1077.

Hoppe, G., Talcott, K.E., Bhattacharya, S.K., Crabb, J.W., Sears, J.E., 2006. Molecular basis for the redox control of nuclear transport of the structural chromatin protein Hmgb1. Experimental Cell Research 312, 3526-3538.

Huang, C.Y.-H., Butrapet, S., Tsuchiya, K.R., Bhamarapravati, N., Gubler, D.J., Kinney, R.M., 2003. Dengue 2 PDK-53 virus as a chimeric carrier for tetravalent dengue vaccine development. Journal of Virology 77, 11436-11447.

Huebner, K., Cannizzaro, L., Frey, A., Hecht, B., Hecht, F., Croce, C., Wallner, B., 1988. Chromosomal localization of the human genes for lipocortin I and lipocortin II. Oncogene Research 2, 299-310.

Hung, S.-L., Lee, P.-L., Chen, H.-W., Chen, L.-K., Kao, C.-L., King, C.-C., 1999. Analysis of the steps involved in Dengue virus entry into host cells. Virology 257, 156-167.

Husainy, A.N., Morrow, A.A., Perkins, T.J., Lee, J.M., 2010. Robust patterns in the stochastic organization of filopodia. BMC Cell Biology 11, 86.

Ichiyama, K., Reddy, S.B.G., Zhang, L.F., Chin, W.X., Muschin, T., Heinig, L., Suzuki, Y., Nanjundappa, H., Yoshinaka, Y., Ryo, A., 2013. Sulfated polysaccharide, curdlan sulfate, efficiently prevents entry/fusion and restricts antibody-dependent enhancement of dengue virus infection in vitro: a possible candidate for clinical application. PLoS Neglected Tropical Dis 7, e2188.

Ikeda, Y., Hayashi, I., Kamoshita, E., Yamazaki, A., Endo, H., Ishihara, K., Yamashina, S., Tsutsumi, Y., Matsubara, H., Majima, M., 2004. Host stromal bradykinin B2 receptor signaling facilitates tumor-associated angiogenesis and tumor growth. Cancer Research 64, 5178-5185.

Ishii, H., Yoshida, M., Hiraoka, M., Hajjar, K.A., Tanaka, A., Yasukochi, Y., Numano, F., 2001. Recombinant annexin II modulates impaired fibrinolytic activity in vitro and in rat carotid artery. Circulation Research 89, 1240-1245.

Jan, J.-T., Chen, B.-H., Ma, S.-H., Liu, C.-I., Tsai, H.-P., Wu, H.-C., Jiang, S.-Y., Yang, K.-D., Shaio, M.-F., 2000. Potential dengue virus-triggered apoptotic pathway in human neuroblastoma cells: arachidonic acid, superoxide anion, and NF-κB are sequentially involved. Journal of Virology 74, 8680-8691.

Jansen, S., Collins, A., Yang, C., Rebowski, G., Svitkina, T., Dominguez, R., 2011. Mechanism of actin filament bundling by fascin. Journal of Biological Chemistry 286, 30087-30096.

Jindal, H.K., Chaney, W.G., Anderson, C.W., Davis, R.G., Vishwanatha, J.K., 1991. The protein-tyrosine kinase substrate, calpactin I heavy chain (p36), is part of the primer recognition protein complex that interacts with DNA polymerase alpha. Journal of Biological Chemistry 266, 5169-5176.

Johnsson, N., Marriott, G., Weber, K., 1988. p36, the major cytoplasmic substrate of src tyrosine protein kinase, binds to its p11 regulatory subunit via a short amino-terminal amphiphatic helix. The EMBO Journal 7, 2435.

Jones, P.G., Moore, G.J., Waisman, D., 1992. A nonapeptide to the putative F-actin binding site of annexin-II tetramer inhibits its calcium-dependent activation of actin filament bundling. Journal of Biological Chemistry 267, 13993-13997.

Jost, M., Gerke, V., 1996. Mapping of a regulatory important site for protein kinase C phosphorylation in the N-terminal domain of annexin II. Biochimica et Biophysica Acta (BBA)-Molecular Cell Research 1313, 283-289.

Kadir, S.L.A., Yaakob, H., Zulkifli, R.M., 2013. Potential anti-dengue medicinal plants: a review. Journal of Natural Medicines 67, 677-689.

Kassam, G., Manro, A., Braat, C.E., Louie, P., Fitzpatrick, S.L., Waisman, D.M., 1997. Characterization of the heparin binding properties of annexin II tetramer. Journal of Biological Chemistry 272, 15093-15100.

Kato, D., Era, S., Watanabe, I., Arihara, M., Sugiura, N., Kimata, K., Suzuki, Y., Morita, K., Hidari, K.I., Suzuki, T., 2010. Antiviral activity of chondroitin sulphate E targeting dengue virus envelope protein. Antiviral Research 88, 236-243.

Kiang, J.G., Koenig, M.L., Smallridge, R.C., 1992. Heat shock increases cytosolic free Ca2+ concentration via Na (+)-Ca2+ exchange in human epidermoid A 431 cells. American Journal of Physiology-Cell Physiology 263, C30-C38.

Kieffer, T.L., George, S., 2014. Resistance to hepatitis C virus protease inhibitors. Current Opinion in Virology 8, 16-21.

Klatt, P., Lamas, S., 2000. Regulation of protein function by S-glutathiolation in response to oxidative and nitrosative stress. European Journal of Biochemistry 267, 4928-4944.

Köhler, G., Hering, U., Zschörnig, O., Arnold, K., 1997. Annexin V interaction with phosphatidylserine-containing vesicles at low and neutral pH. Biochemistry 36, 8189-8194.

Kostyuchenko, V.A., Zhang, Q., Tan, J.L., Ng, T.-S., Lok, S.-M., 2013. Immature and mature dengue serotype 1 virus structures provide insight into the maturation process. Journal of Virology 87, 7700-7707.

Kozma, R., Ahmed, S., Best, A., Lim, L., 1995. The Ras-related protein Cdc42Hs and bradykinin promote formation of peripheral actin microspikes and filopodia in Swiss 3T3 fibroblasts. Molecular and Cellular Biology 15, 1942-1952.

Kramer, M., Reinartz, J., Brunner, G., Schirrmacher, V., 1993. Plasmin in pericellular proteolysis and cellular invasion. Invasion & Metastasis 14, 210-222.

Krause, M., Dent, E.W., Bear, J.E., Loureiro, J.J., Gertler, F.B., 2003. Ena/VASP proteins: regulators of the actin cytoskeleton and cell migration. Annual Review of Cell and Developmental Biology 19, 541-564.

Krugmann, S., Jordens, I., Gevaert, K., Driessens, M., Vandekerckhove, J., Hall, A., 2001. Cdc42 induces filopodia by promoting the formation of an IRSp53: Mena complex. Current Biology 11, 1645-1655.

Kuadkitkan, A., Wikan, N., Fongsaran, C., Smith, D.R., 2010. Identification and characterization of prohibitin as a receptor protein mediating DENV-2 entry into insect cells. Virology 406, 149-161.

Kuhn, R.J., Zhang, W., Rossmann, M.G., Pletnev, S.V., Corver, J., Lenches, E., Jones, C.T., Mukhopadhyay, S., Chipman, P.R., Strauss, E.G., 2002. Structure of dengue virus: implications for flavivirus organization, maturation, and fusion. Cell 108, 717-725.

Kumar, R., Agrawal, T., Khan, N.A., Nakayama, Y., Medigeshi, G.R., 2016. Identification and characterization of the role of c-terminal Src kinase in dengue virus replication. Scientific Reports 6.

Lai, C.-K., Jeng, K.-S., Machida, K., Lai, M.M., 2008. Association of hepatitis C virus replication complexes with microtubules and actin filaments is dependent on the interaction of NS3 and NS5A. Journal of Virology 82, 8838-8848.

Lam, J.H., Ong, L.C., Alonso, S., 2016. Key concepts, strategies, and challenges in dengue vaccine development: an opportunity for sub-unit candidates. Expert Review of Vaccines 15, 483-495.

Langen, R., Isas, J.M., Hubbell, W.L., Haigler, H.T., 1998. A transmembrane form of annexin XII detected by site-directed spin labeling. Proceedings of the National Academy of Sciences 95, 14060-14065.

Lauvrak, S.U., Hollås, H., Døskeland, A.P., Aukrust, I., Flatmark, T., Vedeler, A., 2005. Ubiquitinated annexin A2 is enriched in the cytoskeleton fraction. FEBS Letters 579, 203-206.

Law, A.-L., Ling, Q., Hajjar, K.A., Futter, C.E., Greenwood, J., Adamson, P., Wavre-Shapton, S.T., Moss, S.E., Hayes, M.J., 2009. Annexin A2 regulates phagocytosis of photoreceptor outer segments in the mouse retina. Molecular Biology of the Cell 20, 3896-3904.

LeBouder, F., Morello, E., Rimmelzwaan, G.F., Bosse, F., Péchoux, C., Delmas, B., Riteau, B., 2008. Annexin II incorporated into influenza virus particles supports virus replication by converting plasminogen into plasmin. Journal of Virology 82, 6820-6828.

Lee, E., Wright, P.J., Davidson, A., Lobigs, M., 2006. Virulence attenuation of Dengue virus due to augmented glycosaminoglycan-binding affinity and restriction in extraneural dissemination. Journal of General Virology 87, 2791-2801.

Lehmann, M.J., Sherer, N.M., Marks, C.B., Pypaert, M., Mothes, W., 2005. Actin-and myosin-driven movement of viruses along filopodia precedes their entry into cells. The Journal of Cell Biology 170, 317-325.

Lei, H., Romeo, G., Kazlauskas, A., 2004. Heat Shock Protein 90α–Dependent Translocation of Annexin II to the Surface of Endothelial Cells Modulates Plasmin Activity in the Diabetic Rat Aorta. Circulation Research 94, 902-909.

Li, L., Lok, S.-M., Yu, I.-M., Zhang, Y., Kuhn, R.J., Chen, J., Rossmann, M.G., 2008. The flavivirus precursor membrane-envelope protein complex: structure and maturation. Science 319, 1830-1834.

Ligon, B.L., 2005. Dengue fever and dengue hemorrhagic fever: a review of the history, transmission, treatment, and prevention, Seminars in pediatric infectious diseases. WB Saunders, pp. 60-65.

Lin, C.-F., Wan, S.-W., Cheng, H.-J., Lei, H.-Y., Lin, Y.-S., 2006. Autoimmune pathogenesis in dengue virus infection. Viral Immunology 19, 127-132.

Ling, Q., Jacovina, A.T., Deora, A., Febbraio, M., Simantov, R., Silverstein, R.L., Hempstead, B., Mark, W.H., Hajjar, K.A., 2004. Annexin II regulates fibrin homeostasis and neoangiogenesis in vivo. The Journal of Clinical Investigation 113, 38-48.

Liu, Y., Myrvang, H.K., Dekker, L.V., 2015. Annexin A2 complexes with S100 proteins: structure, function and pharmacological manipulation. British Journal of Pharmacology 172, 1664-1676.

Lizarbe, M.A., Barrasa, J.I., Olmo, N., Gavilanes, F., Turnay, J., 2013. Annexin-phospholipid interactions. Functional implications. International Journal of Molecular Sciences 14, 2652-2683.

Low C. Y., 2014. Ultrastructural study on sylvatic dengue virus infection in Vero and U937 cells. M Sc. Thesis, Universiti Putra Malaysia.

Lozach, P.-Y., Burleigh, L., Staropoli, I., Navarro-Sanchez, E., Harriague, J., Virelizier, J.-L., Rey, F.A., Desprès, P., Arenzana-Seisdedos, F., Amara, A., 2005. Dendritic cell-specific intercellular adhesion molecule 3-grabbing non-integrin (DC-SIGN)-mediated enhancement of dengue virus infection is independent of DC-SIGN internalization signals. Journal of Biological Chemistry 280, 23698-23708.

Luo, M., Hajjar, K.A., 2013. Annexin A2 system in human biology: cell surface and beyond, Seminars in thrombosis and hemostasis. Thieme Medical Publishers, pp. 338-346.

Ma, L., Jones, C.T., Groesch, T.D., Kuhn, R.J., Post, C.B., 2004. Solution structure of dengue virus capsid protein reveals another fold. Proceedings of the National Academy of Sciences of the United States of America 101, 3414-3419.

Marovitch, M., Grouard-Vogel, G., Eller, M., Tassaneetrithep, B., Birx, D., Hayes, C., Schlesinger-Frankel, S., Louder, M., Mascola, J., Sun, W., 2001. Human dendritic cells as targets of dengue virus infection, Journal of Investigative Dermatology Symposium Proceedings. Elsevier, pp. 219-224.

Marsh, M., Helenius, A., 2006. Virus entry: open sesame. Cell 124, 729-740.

Mattila, P.K., Lappalainen, P., 2008. Filopodia: molecular architecture and cellular functions. Nature Reviews Molecular Cell Biology 9, 446-454.

Matunis, M.J., Coutavas, E., Blobel, G., 1996. A novel ubiquitin-like modification modulates the partitioning of the Ran-GTPase-activating protein RanGAP1 between the cytosol and the nuclear pore complex. The Journal of Cell Biology 135, 1457-1470.

McCready, J., Sims, J.D., Chan, D., Jay, D.G., 2010. Secretion of extracellular hsp90α via exosomes increases cancer cell motility: a role for plasminogen activation. BMC Cancer 10, 294.

Meertens, L., Carnec, X., Lecoin, M.P., Ramdasi, R., Guivel-Benhassine, F., Lew, E., Lemke, G., Schwartz, O., Amara, A., 2012. The TIM and TAM families of phosphatidylserine receptors mediate dengue virus entry. Cell Host & Microbe 12, 544-557.

Menell, J.S., Cesarman, G.M., Jacovina, A.T., McLaughlin, M.A., Lev, E.A., Hajjar, K.A., 1999. Annexin II and bleeding in acute promyelocytic leukemia. New England Journal of Medicine 340, 994-1004.

Mercer, J., Helenius, A., 2008. Vaccinia virus uses macropinocytosis and apoptotic mimicry to enter host cells. Science 320, 531-535.

Miller, J.L., Barend, J., Martinez-Pomares, L., Radcliffe, C.M., Dwek, R.A., Rudd, P.M., Gordon, S., 2008. Correction: The Mannose Receptor Mediates Dengue Virus Infection of Macrophages. PLoS Pathogens 4.

Modig, H., 1968. Cellular mixed disulphides between thiols and proteins, and their possible implication for radiation protection. Biochemical Pharmacology 17, 177-186.

Modis, Y., Ogata, S., Clements, D., Harrison, S.C., 2003. A ligand-binding pocket in the dengue virus envelope glycoprotein. Proceedings of the National Academy of Sciences 100, 6986-6991.

Modis, Y., Ogata, S., Clements, D., Harrison, S.C., 2004. Structure of the dengue virus envelope protein after membrane fusion. Nature 427, 313-319.

Modis, Y., Ogata, S., Clements, D., Harrison, S.C., 2005. Variable surface epitopes in the crystal structure of dengue virus type 3 envelope glycoprotein. Journal of Virology 79, 1223-1231.

Monath, T.P., 1994. Dengue: the risk to developed and developing countries. Proceedings of the National Academy of Sciences 91, 2395-2400.

Mondotte, J.A., Lozach, P.-Y., Amara, A., Gamarnik, A.V., 2007. Essential role of dengue virus envelope protein N glycosylation at asparagine-67 during viral propagation. Journal of Virology 81, 7136-7148.

Mongkolsapaya, J., Dejnirattisai, W., Xu, X.-n., Vasanawathana, S., Tangthawornchaikul, N., Chairunsri, A., Sawasdivorn, S., Duangchinda, T., Dong, T., Rowland-Jones, S., 2003. Original antigenic sin and apoptosis in the pathogenesis of dengue hemorrhagic fever. Nature Medicine 9, 921-927.

Montaville, P., Neumann, J.-M., Russo-Marie, F., Ochsenbein, F., Sanson, A., 2002. A new consensus sequence for phosphatidylserine recognition by annexins. Journal of Biological Chemistry 277, 24684-24693.

Morel, E., Gruenberg, J., 2009. Annexin A2 binding to endosomes and functions in endosomal transport are regulated by tyrosine 23 phosphorylation. Journal of Biological Chemistry 284, 1604-1611.

Mosso, C., Galván-Mendoza, I.J., Ludert, J.E., del Angel, R.M., 2008. Endocytic pathway followed by dengue virus to infect the mosquito cell line C6/36 HT. Virology 378, 193-199.

Nakagawa, H., Miki, H., Nozumi, M., Takenawa, T., Miyamoto, S., Wehland, J., Small, J.V., 2003. IRSp53 is colocalised with WAVE2 at the tips of protruding lamellipodia and filopodia independently of Mena. Journal of Cell Science 116, 2577-2583.

Navarro-Sanchez, E., Altmeyer, R., Amara, A., Schwartz, O., Fieschi, F., Virelizier, J.L., Arenzana-Seisdedos, F., Desprès, P., 2003. Dendritic-cell-specific ICAM3-grabbing non-integrin is essential for the productive infection of human dendritic cells by mosquito-cell-derived dengue viruses. EMBO Reports 4, 723-728.

Noisakran, S., Onlamoon, N., Songprakhon, P., Hsiao, H.-M., Chokephaibulkit, K., Perng, G.C., 2010. Cells in dengue virus infection in vivo. Advances in Virology 2010.

Okuse, K., Malik-Hall, M., Baker, M.D., Poon, W.L., Kong, H., Chao, M.V., Wood, J.N., 2002. Annexin II light chain regulates sensory neuron-specific sodium channel expression. Nature 417, 653-656.

World Health Organization., 2009. Special Programme for Reseearch, Training in Tropical Diseases, World Health Organization. Department of Control of Neglected Tropical Diseases, World Health Organization. Epidemic, and Pandemic Alert. Dengue: guidelines for diagnosis, treatment prevention and control. World Health Organization.

Osorio, J.E., Huang, C.Y.-H., Kinney, R.M., Stinchcomb, D.T., 2011. Development of DENVax: a chimeric dengue-2 PDK-53-based tetravalent vaccine for protection against dengue fever. Vaccine 29, 7251-7260.

Osorio, J.E., Partidos, C.D., Wallace, D., Stinchcomb, D.T., 2015. Development of a recombinant, chimeric tetravalent dengue vaccine candidate. Vaccine 33, 7112-7120.

Paingankar, M.S., Gokhale, M.D., Deobagkar, D.N., 2010. Dengue-2-virus-interacting polypeptides involved in mosquito cell infection. Archives of Virology 155, 1453-1461.

Pang, E.L., Loh, H.-S., 2016. Current perspectives on dengue episode in Malaysia. Asian Pacific Journal of Tropical Medicine 9, 395-401.

Pelchen-Matthews, A., Kramer, B., Marsh, M., 2003. Infectious HIV-1 assembles in late endosomes in primary macrophages. The Journal of Cell Biology 162, 443-455.

Pelkmans, L., Püntener, D., Helenius, A., 2002. Local actin polymerization and dynamin recruitment in SV40-induced internalization of caveolae. Science 296, 535-539.

Pennings, P.S., 2013. HIV drug resistance: problems and perspectives. Infectious disease reports, 5(Suppl 1).

Perera, R., Kuhn, R.J., 2008. Structural proteomics of dengue virus. Current Opinion in Microbiology 11, 369-377.

Petrovic, N., Schacke, W., Gahagan, J.R., O'Conor, C.A., Winnicka, B., Conway, R.E., Mina-Osorio, P., Shapiro, L.H., 2007. CD13/APN regulates endothelial invasion and filopodia formation. Blood 110, 142-150.

Piccini, L.E., Castilla, V., Damonte, E.B., 2015. Dengue-3 Virus Entry into Vero Cells: Role of Clathrin-Mediated Endocytosis in the Outcome of Infection. PloS one 10, e0140824.

Pokidysheva, E., Zhang, Y., Battisti, A.J., Bator-Kelly, C.M., Chipman, P.R., Xiao, C., Gregorio, G.G., Hendrickson, W.A., Kuhn, R.J., Rossmann, M.G., 2006. Cryo-EM reconstruction of dengue virus in complex with the carbohydrate recognition domain of DC-SIGN. Cell 124, 485-493.

Pollard, T.D., Borisy, G.G., 2003. Cellular motility driven by assembly and disassembly of actin filaments. Cell 112, 453-465.

Randolph, V.B., Winkler, G., Stollar, V., 1990. Acidotropic amines inhibit proteolytic processing of flavivirus prM protein. Virology 174, 450-458.

Regnouf, F., Rendon, A., Pradel, L., 1991. Biochemical characterization of annexins I and II isolated from pig nervous tissue. Journal of Neurochemistry 56, 1985-1996.

Rescher, U., Gerke, V., 2004. Annexins–unique membrane binding proteins with diverse functions. Journal of Cell Science 117, 2631-2639.

Rey, F.A., 2013. Dengue virus: two hosts, two structures. Nature 497, 443-444.

Rey, F.A., Heinz, F.X., Mandl, C., Kunz, C., Harrison, S.C., 1995. The envelope glycoprotein from tick-borne encephalitis virus at 2 Å resolution. Nature, 375, 291

Reyes-del Valle, J., Chávez-Salinas, S., Medina, F., del Angel, R.M., 2005. Heat shock protein 90 and heat shock protein 70 are components of dengue virus receptor complex in human cells. Journal of Virology 79, 4557-4567.

Rigau-Pérez, J.G., Clark, G.G., Gubler, D.J., Reiter, P., Sanders, E.J., Vorndam, A.V., 1998. Dengue and dengue haemorrhagic fever. The Lancet 352, 971-977.

Rodhain, F., Rosen, L., 1997. Mosquito vectors and dengue virus-vector relationships. Dengue and dengue hemorrhagic fever, Fort collins. Center for Agriculture Bioscience International 2, 26-27.

Roehrig, J.T., Butrapet, S., Liss, N.M., Bennett, S.L., Luy, B.E., Childers, T., Boroughs, K.L., Stovall, J.L., Calvert, A.E., Blair, C.D., 2013. Mutation of the dengue virus type 2 envelope protein heparan sulfate binding sites or the domain III lateral ridge blocks replication in Vero cells prior to membrane fusion. Virology 441, 114-125.

Rossmann, M.G., Morais, M.C., Leiman, P.G., Zhang, W., 2005. Combining X-ray crystallography and electron microscopy. Structure 13, 355-362.

Rothman, A.L., Ennis, F.A., 1999. Immunopathogenesis of dengue hemorrhagic fever. Virology 257, 1-6.

Ryzhova, E.V., Vos, R.M., Albright, A.V., Harrist, A.V., Harvey, T., González-Scarano, F., 2006. Annexin 2: a novel human immunodeficiency virus type 1 Gag binding protein involved in replication in monocyte-derived macrophages. Journal of Virology 80, 2694-2704.

Sakoonwatanyoo, P., Boonsanay, V., Smith, D.R., 2006. Growth and production of the dengue virus in C6/36 cells and identification of a laminin-binding protein as a candidate serotype 3 and 4 receptor protein. Intervirology 49, 161-172.

Sakumura, Y., Tsukada, Y., Yamamoto, N., Ishii, S., 2005. A molecular model for axon guidance based on cross talk between rho GTPases. Biophysical Journal 89, 812-822.

Sakuntabhai, A., Turbpaiboon, C., Casadémont, I., Chuansumrit, A., Lowhnoo, T., Kajaste-Rudnitski, A., Kalayanarooj, S.M., Tangnararatchakit, K., Tangthawornchaikul, N., Vasanawathana, S., 2005. A variant in the CD209 promoter is associated with severity of dengue disease. Nature Genetics 37, 507-513.

Saxena, V., Lai, C.-K., Chao, T.-C., Jeng, K.-S., Lai, M.M., 2012. Annexin A2 is involved in the formation of hepatitis C virus replication complex on the lipid raft. Journal of Virology 86, 4139-4150.

Schnell, J.D., Hicke, L., 2003. Non-traditional functions of ubiquitin and ubiquitin-binding proteins. Journal of Biological Chemistry 278, 35857-35860.

Schnitzer, J.E., Liu, J., Oh, P., 1995. Endothelial caveolae have the molecular transport machinery for vesicle budding, docking, and fusion including VAMP, NSF, SNAP, annexins, and GTPases. Journal of Biological Chemistry 270, 14399-14404.

Screaton, G., Mongkolsapaya, J., Yacoub, S., Roberts, C., 2015. New insights into the immunopathology and control of dengue virus infection. Nature Reviews Immunology 15, 745-759.

Shao, C., Zhang, F., Kemp, M.M., Linhardt, R.J., Waisman, D.M., Head, J.F., Seaton, B.A., 2006. Crystallographic analysis of calcium-dependent heparin binding to annexin A2. Journal of Biological Chemistry 281, 31689-31695.

Sharma-Walia, N., Naranatt, P.P., Krishnan, H.H., Zeng, L., Chandran, B., 2004. Kaposi's sarcoma-associated herpes virus/human herpes virus 8 envelope glycoprotein gB induces the integrin-dependent focal adhesion kinase-Src-phosphatidylinositol 3-kinase-rho GTPase signal pathways and cytoskeletal rearrangements. Journal of virology 78, 4207-4223.

Sheng, C., Liu, X., Jiang, Q., Xu, B., Zhou, C., Wang, Y., Chen, J., Xiao, M., 2015. Annexin A2 is involved in the production of classical swine fever virus infectious particles. Journal of General Virology 96, 1027-1032.

Smith, J.L., Lidke, D.S., Ozbun, M.A., 2008. Virus activated filopodia promote human papillomavirus type 31 uptake from the extracellular matrix. Virology 381, 16-21.

Sousa, A.D., Cheney, R.E., 2005. Myosin-X: a molecular motor at the cell's fingertips. Trends in Cell Biology 15, 533-539.

Steinhauer, D.A., 1999. Role of hemagglutinin cleavage for the pathogenicity of influenza virus. Virology 258, 1-20.

Su, S.-C., Maxwell, S.A., Bayless, K.J., 2010. Annexin 2 regulates endothelial morphogenesis by controlling AKT activation and junctional integrity. Journal of Biological Chemistry 285, 40624-40634.

Sullivan, D.M., Wehr, N.B., Fergusson, M.M., Levine, R.L., Finkel, T., 2000. Identification of oxidant-sensitive proteins: TNF-α induces protein glutathiolation. Biochemistry 39, 11121-11128.

Thepparit, C., Smith, D.R., 2004. Serotype-specific entry of dengue virus into liver cells: identification of the 37-kilodalton/67-kilodalton high-affinity laminin receptor as a dengue virus serotype 1 receptor. Journal of Virology 78, 12647-12656.

Thiel, C., Osborn, M., Gerke, V., 1992. The tight association of the tyrosine kinase substrate annexin II with the submembranous cytoskeleton depends on intact p11-and Ca (2+)-binding sites. Journal of Cell Science 103, 733-742.

Thomas, S.J., Endy, T.P., 2011. Critical issues in dengue vaccine development. Current Opinion in Infectious Diseases 24, 442-450.

Tio, P.H., Jong, W.W., Cardosa, M.J., 2005. Two dimensional VOPBA reveals laminin receptor (LAMR1) interaction with dengue virus serotypes 1, 2 and 3. Virology Journal 2, 1.

Tokuo, H., Mabuchi, K., Ikebe, M., 2007. The motor activity of myosin-X promotes actin fiber convergence at the cell periphery to initiate filopodia formation. The Journal of Cell Biology 179, 229-238.

Turpin, E., Russo-Marie, F., Dubois, T., de Paillerets, C., Alfsen, A., Bomsel, M., 1998. In adrenocortical tissue, annexins II and VI are attached to clathrin coated vesicles in a calcium-independent manner. Biochimica et Biophysica Acta (BBA)-Molecular Cell Research 1402, 115-130.

Upanan, S., Kuadkitkan, A., Smith, D.R., 2008. Identification of dengue virus binding proteins using affinity chromatography. Journal of Virological Methods 151, 325-328.

van der Vries, E., Schutten, M., Fraaij, P., Boucher, C., Osterhaus, A., 2013. Influenza virus resistance to antiviral therapy. Advance Pharmacology 67, 217-246.

Vaughn, D.W., Green, S., Kalayanarooj, S., Innis, B.L., Nimmannitya, S., Suntayakorn, S., Endy, T.P., Raengsakulrach, B., Rothman, A.L., Ennis, F.A., 2000. Dengue viremia titer, antibody response pattern, and virus serotype correlate with disease severity. Journal of Infectious Diseases 181, 2-9.

Vignjevic, D., Kojima, S.-i., Aratyn, Y., Danciu, O., Svitkina, T., Borisy, G.G., 2006. Role of fascin in filopodial protrusion. The Journal of Cell Biology 174, 863-875.

Villar, L., Dayan, G.H., Arredondo-García, J.L., Rivera, D.M., Cunha, R., Deseda, C., Reynales, H., Costa, M.S., Morales-Ramírez, J.O., Carrasquilla, G., 2015. Efficacy of a tetravalent dengue vaccine in children in Latin America. New England Journal of Medicine 372, 113-123.

Vlasak, M., Goesler, I., Blaas, D., 2005. Human rhinovirus type 89 variants use heparan sulfate proteoglycan for cell attachment. Journal of Virology 79, 5963-5970.

Waisman, D.M., 1995. Annexin II tetramer: structure and function, Signal Transduction Mechanisms. Springer, pp. 301-322.

Wang, S., He, R., Patarapotikul, J., Innis, B.L., Anderson, R., 1995. Antibody-enhanced binding of dengue-2 virus to human platelets. Virology 213, 254-257.

Watanabe, K., Fuse, T., Asano, I., Tsukahara, F., Maru, Y., Nagata, K., Kitazato, K., Kobayashi, N., 2006. Identification of Hsc70 as an influenza virus matrix protein (M1) binding factor involved in the virus life cycle. FEBS Letters 580, 5785-5790.

Wei, H.-Y., Jiang, L.-F., Fang, D.-Y., Guo, H.-Y., 2003. Dengue virus type 2 infects human endothelial cells through binding of the viral envelope glycoprotein to cell surface polypeptides. Journal of General Virology 84, 3095-3098.

Welch, M.D., Mullins, R.D., 2002. Cellular control of actin nucleation. Annual Review of Cell and Developmental Biology 18, 247-288.

Wichit, S., Jittmittraphap, A., Hidari, K.I., Thaisomboonsuk, B., Petmitr, S., Ubol, S., Aoki, C., Itonori, S., Morita, K., Suzuki, T., 2011. Dengue virus type 2 recognizes the carbohydrate moiety of neutral glycosphingolipids in mammalian and mosquito cells. Microbiology and Immunology 55, 135-140.

Wills, B.A., Oragui, E.E., Stephens, A.C., Daramola, O.A., Dung, N.M., Loan, H.T., Chau, N.V., Chambers, M., Stepniewska, K., Farrar, J.J., 2002. Coagulation abnormalities in dengue hemorrhagic fever: serial investigations in 167 Vietnamese children with dengue shock syndrome. Clinical Infectious Diseases 35, 277-285.

Woodham, A.W., Da Silva, D.M., Skeate, J.G., Raff, A.B., Ambroso, M.R., Brand, H.E., Isas, J.M., Langen, R., Kast, W.M., 2012. The S100A10 subunit of the annexin A2 heterotetramer facilitates L2-mediated human papillomavirus infection. PLOS ONE 7, e43519.

Wright, J., Kurosky, A., Wasi, S., 1994. An endothelial cell-surface form of annexin II binds human cytomegalovirus. Biochemical and Biophysical Research Communications 198, 983-989.

Wright, J.F., Kurosky, A., Pryzdial, E., Wasi, S., 1995. Host cellular annexin II is associated with cytomegalovirus particles isolated from cultured human fibroblasts. Journal of Virology 69, 4784-4791.

WuYang, Z., JiangJiao, L., LIANG, G., 2011. How does cellular heparan sulfate function in viral pathogenicity? Biomedical and Environmental Sciences 24, 81-87.

Xie, Y., Kole, S., Precht, P., Pazin, M.J., Bernier, M., 2009. S-glutathionylation impairs signal transducer and activator of transcription 3 activation and signaling. Endocrinology 150, 1122-1131.

Xu, H., Hao, X., Wang, S., Wang, Z., Cai, M., Jiang, J., Qin, Q., Zhang, M., Wang, H., 2015. Real-time imaging of rabies virus entry into living vero cells. Scientific Reports 5.

Yamagishi, A., Masuda, M., Ohki, T., Onishi, H., Mochizuki, N., 2004. A novel actin bundling/filopodium-forming domain conserved in insulin receptor tyrosine kinase substrate p53 and missing in metastasis protein. Journal of Biological Chemistry 279, 14929-14936.

Yang, C.-F., Su, C.-L., Hsu, T.-C., Chen, L.-Y., Shu, P.-Y., 2014. Surveillance and Molecular Characterization on Dengue Viruses in Taiwan, 2013. Epidemiology Bulletin 30, 157-170.

Yang, C., Czech, L., Gerboth, S., Kojima, S.-i., Scita, G., Svitkina, T., 2007. Novel roles of formin mDia2 in lamellipodia and filopodia formation in motile cells. PLoS Biology 5, e317.

Yang, J., Zou, L., Hu, Z., Chen, W., Zhang, J., Zhu, J., Fang, X., Yuan, W., Hu, X., Hu, F., 2013. Identification and characterization of a 43 kDa actin protein involved in the DENV-2 binding and infection of ECV304 cells. Microbes and Infection 15, 310-318.

Yang, S.-L., Chou, Y.-T., Wu, C.-N., Ho, M.-S., 2011. Annexin II binds to capsid protein VP1 of enterovirus 71 and enhances viral infectivity. Journal of Virology 85, 11809-11820.

Yauch, L.E., Shresta, S., 2014. Dengue virus vaccine development. Advances in Virus Research 88, 315-372.

Yu, I.-M., Holdaway, H.A., Chipman, P.R., Kuhn, R.J., Rossmann, M.G., Chen, J., 2009. Association of the pr peptides with dengue virus at acidic pH blocks membrane fusion. Journal of Virology 83, 12101-12107.

Yu, I.-M., Zhang, W., Holdaway, H.A., Li, L., Kostyuchenko, V.A., Chipman, P.R., Kuhn, R.J., Rossmann, M.G., Chen, J., 2008. Structure of the immature dengue virus at low pH primes proteolytic maturation. Science 319, 1834-1837.

Zamudio-Meza, H., Castillo-Alvarez, A., González-Bonilla, C., Meza, I., 2009. Cross-talk between Rac1 and Cdc42 GTPases regulates formation of filopodia required for dengue virus type-2 entry into HMEC-1 cells. Journal of General Virology 90, 2902-2911.

Zeuschner, D., Stoorvogel, W., Gerke, V., 2001. Association of annexin 2 with recycling endosomes requires either calcium-or cholesterol-stabilized membrane domains. European Journal of Cell Biology 80, 499-507.

Zhang, J.-l., Wang, J.-l., Gao, N., Chen, Z.-t., Tian, Y.-p., An, J., 2007. Up-regulated expression of β3 integrin induced by dengue virus serotype 2 infection associated with virus entry into human dermal microvascular endothelial cells. Biochemical and Biophysical Research Communications 356, 763-768.

Zhang, W., Chipman, P.R., Corver, J., Johnson, P.R., Zhang, Y., Mukhopadhyay, S., Baker, T.S., Strauss, J.H., Rossmann, M.G., Kuhn, R.J., 2003. Visualization of membrane protein domains by cryo-electron microscopy of dengue virus. Nature Structural & Molecular Biology 10, 907-912.

Zhang, X., Ge, P., Yu, X., Brannan, J.M., Bi, G., Zhang, Q., Schein, S., Zhou, Z.H., 2013a. Cryo-EM structure of the mature dengue virus at 3.5-Å resolution. Nature Structural & Molecular Biology 20, 105-110.

Zhang, X., Sheng, J., Plevka, P., Kuhn, R.J., Diamond, M.S., Rossmann, M.G., 2013b. Dengue structure differs at the temperatures of its human and mosquito hosts. Proceedings of the National Academy of Sciences 110, 6795-6799.

Zhang, Y., Zhang, W., Ogata, S., Clements, D., Strauss, J.H., Baker, T.S., Kuhn, R.J., Rossmann, M.G., 2004. Conformational changes of the flavivirus E glycoprotein. Structure 12, 1607-1618.

Zhu, X.-J., Wang, C.-Z., Dai, P.-G., Xie, Y., Song, N.-N., Liu, Y., Du, Q.-S., Mei, L., Ding, Y.-Q., Xiong, W.-C., 2007. Myosin X regulates netrin receptors and functions in axonal path-finding. Nature Cell Biology 9, 184-192.

BIODATA OF STUDENT

Isah Abubakar Aliyu, was born in Kano State Nigeria on 21st January 1980. He started his carrier in education at Science Collage Dawakin Kudu, Kano State, Nigeria. He graduated in the year 1998. And later joined Bayero University Kano for his first degree, Bachelor in microbiology. He graduated in 2005, and then proceeded to Federal Collage of Veterinary and Medical Laboratory Science VOM. Where he obtained an Associate Degree in Medical Laboratory Science, with speciality in Medical Microbiology in the year 2008. Isah Abubakar Aliyu was a registered member of Medical Laboratory Science Council of Nigeria (MLSCN) from 2008 to date. Before he joined Bayero University Kano for Master Degree in Medical Microbiology, he worked as a biomedical scientist at various secondary and tertiary health institution in Nigeria. Where his primary schedule was routine medical microbiology experiment and HIV molecular diagnosis and prognosis using virus load assays. He joined service with Bayero University Kano as assistant lecturer in 2012. With primary assignment in organizing and conducting practical, teaching and examination of medical laboratory science students.

LIST OF PUBLICATIONS

Aliyu, I. A., Ling, K. L., Md Hashim, N. F. Chee H. Y. (2019). Annexin A2 Translocation and Virus Interaction; a Potential Target for Antivirus Drug Discovery. Review in medical virology. DOI:10.1002/rmv.2038.

Jamilu A. B., K. N. Balakrishnan1, A. A. Abdullah, L. C. Yi1, A. A. Bitrus1, Y. A, **I. A. Aliyu**, I. D. Peter, I. U. Hambali, R. Bin Mohamed, F. F. A. Jesse, A. Haron, M. M. Noordin, M. A. M. Lila*(2018). Sero-epidemiology of Contagious Ecthyma Based on Detection of IgG Antibody in Selected Sheep and Goats Farms in Malaysia. Advances in Animal and Veterinary Sciences 6(5): 219-226. ISSN (Online) | 2307-8316; ISSN (Print) | 2309-3331

Kabir I. M., Abdulkadir, S., Yusuf, L., Doro, A.B., Kumurya, A.S., Bala, J. A., and **Aliyu, I.A**.* (2018). Threat of Occult Hepatitis B Virus Infection: A Major Issue in Blood Transfusion Services. Sokoto Journal of Medical Laboratory Science. 3 (2)-003

Audu, U. and **I. A. Aliyu*** (2018). Plasmodium Falciparum Host Cells Surface Receptor as a Target for Development of Novel Antimalarial Therapeutics. Bayero Journal of Medical Laboratory Science. 3(1): ISSN 2545 – 5672

Aliyu, B. D., I. M. Kabir, A. Sa'idu, Y. Lukman, A. S. KUMURYA, J. A. Bala, and **I. A. Aliyu*** (2018). Use of IL-6, IL-8 and IL-12 as Prognostic Markers for HBV Infection Progression to Hepatocellular Carcinoma. Bayero Journal of Medical Laboratory Science. 3(1): ISSN 2545 – 5672

Aliyu. I. A., AS Kumurya, JA Bala, OC John (2017). Bacteriology of Otitis Media and Its Host-Environmental-Infection Factors. Asia Pacific Environmental and Occupational Health Journal 3 (1) ISSN 2462 -2214

Aliyu, I. A, Bala, J. A. and Maqsood, M. (2016): Autism, a surge in the prevalence and linkage with childhood vaccination- A review. Bayero Journal of Medical Laboratory Science. 1(1): 14 – 25. ISSN 2545 – 5672

Yahaya H., Taura D. W., **Aliyu I. A**., Bala J. A., Yunusa I., Ahmad I. M., Ali B. (2015). Spectrum of opportunistic mould infections in suspected pulmonary tuberculosis (TB) patients. International Journal of Microbiology and Application 2(1): 6-11, available online at (http://www.openscienceonline.com/journal/ijma)

Bala JA., Kawo AH., Mukhtar MD., Sarki A., Magaji N., **Aliyu I. A**. and Sani MN (2012). Prevalence of hepatitis c virus infection among blood donors in some selected hospitals in Kano, Nigeria. International Research Journal of Microbiology. Vol.3 (6) 217-222, (ISSN:2141-5463) available online http//www.intersjournals.org/irjm

Yusuf I., Magashi AM. , Firdausi FS., Sharif AA., Getso MI., Bala JI., **Aliyu I. A**. (2012). Phenotypic detection of carbapenemases in members of enterobacteriacea in

Kano, Nigeria. International Journal of Science and Technology. vol.7 no.11. nov.2012. (ISSN: 2224-3577)

Yusuf I, Yushau M., Sharif AA., Getso M., Yahaya H., Bala JA., **Aliyu I. A.** (2012). Detection of metallobetalactamase among gram negative bacterial isolates from Murtala Muhammad Specialist Hospital, Kano and Almadina Hospital Kaduna, Nigeria. Bayero Journal of Pure and Applied Sciences. 5(2):84-88 (ISSN:2006-6996)

Book and book chapters

Aliyu I. A, Bala JA, Yayo AM (2015). Post LLINs malaria burden in Tudun Wada, Kano Nigeria. A book published by lambert academic press. Available on line at http://dnb.d-nb.de. ISBN: 978-3-659-80282-9.

CONFERENCE PAPER PRESENTATIONS

Aliyu. I. A., AS Kumurya, JA Bala, OC John (2017). Bacteriology of Otitis Media and Its Host-Environmental-Infection Factors. 2nd International Conference of Environmental and Occupational Health (ICEOH). Putrajaya Marriott Hotel, Malaysia April 2016.

Aliyu IA., Yayo AM., and Muktar MD., (2011). Effectiveness of insecticide treated nets (ITNs) in the control of malaria in Tudun wada local government area, Kano state Nigeria. Book of abstract, 9th annual conference of association of medical laboratory scientist. Kano branch.

Bala JA., Kawo A.H., Muktar M.D and **Aliyu IA**., (2011): Quality Evaluation of One Step Rapid Screening Test for the Detection of Hepatitis C Virus among Blood Donors in Kano, Nigeria. Proceeding of 9th annual conference association of medical laboratory scientist. Kano branch.

Aliyu IA., John O.C., Bala JA., and Tofa UA (2011). Bacteriology of Otitis Media, in Patients Attending Jos University Teaching Hospital, Jos, Platuea, Nigeria. Proceeding of 9th annual conference association of medical laboratory scientist. Kano branch.

Bala JA., Junaid S.A., **I, A. Aliyu** and Muhammad A., (2013): Bacteriology of Wound Infection Associated with Diabetic Patients in Jos University Teaching Hospital, Plateau state, Nigeria. Proceeding of National conference of the Association of Medical Laboratory Scientist of Nigeria.

Aliyu I. A., Yayo AM., Bala JA., Yahaya H., and Tukur A., (2013). Impact Assessment of Long-Lasting Insecticide Treated Nets (LLINs) in the Control of Malaria, in Tudun Wada LGA Kano State, Nigeria. Proceeding of National conference of the Association of Medical Laboratory Scientist of Nigeria. Held at Ibrahim Shema Conference Hall, Katsina State.

UNIVERSITI PUTRA MALAYSIA

STATUS CONFIRMATION FOR THESIS / PROJECT REPORT AND COPYRIGHT

ACADEMIC SESSION: First Semester 2018/2019

TITLE OF THESIS / PROJECT REPORT:

MOLECULAR IDENTIFICATION OF DENGUE VIRUS BINDING PROTEIN ON FILOPODIA OF VERO CELLS

NAME OF STUDENT: ISAH ABUBAKAR ALIYU

I acknowledge that the copyright and other intellectual property in the thesis/project report belonged to Universiti Putra Malaysia and I agree to allow this thesis/project report to be placed at the library under the following terms:

1. This thesis/project report is the property of Universiti Putra Malaysia.

2. The library of Universiti Putra Malaysia has the right to make copies for educational purposes only.

3. The library of Universiti Putra Malaysia is allowed to make copies of this thesis for academic exchange.

I declare that this thesis is classified as:

*Please tick (√)

☐	**CONFIDENTIAL**	(Contain confidential information under Official Secret Act 1972).
☐	**RESTRICTED**	(Contains restricted information as specified by the organization/institution where research was done).
☐	**OPEN ACCESS**	I agree that my thesis/project report to be published as hard copy or online open access.

This thesis is submitted for:

☐	**PATENT**	Embargo from_____until _____ **(date)** **(date)**

Approved by:

_____ _____

(Signature of Student) (Signature of Chairman of Supervisory Committee)
New IC No/ Passport No.: Name:
Date:

Date:

[Note: If the thesis is CONFIDENTIAL or RESTRICTED, please attach with the letter from the organization/institution with period and reasons for confidentially or restricted]