



Universiteit
Leiden
The Netherlands

The unexplored functions of Toll-like receptor signaling: immunometabolism, development and microbiome interactions

Liu, L.

Citation

Liu, L. (2026, March 17). *The unexplored functions of Toll-like receptor signaling: immunometabolism, development and microbiome interactions*. Retrieved from <https://hdl.handle.net/1887/4297285>

Version: Publisher's Version

License: [Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden](#)

Downloaded from: <https://hdl.handle.net/1887/4297285>

Note: To cite this publication please use the final published version (if applicable).

**The unexplored functions of Toll-like receptor
signaling: Immunometabolism, development and
microbiome interactions**

Li Liu

2026, Leiden

The unexplored functions of Toll-like receptor signaling: Immunometabolism, development and microbiome interactions

© Li Liu, Leiden, the Netherlands, 2026

All rights reserved. No part of this thesis may be reproduced or transmitted, in any form or by any means, without prior written permission of the author.

ISBN: 978-94-6496-532-2

The work presented in this thesis was carried out at the Institute of Biology Leiden, Leiden University, and supported by the China Scholarship Council (CSC 202108210105)

Cover design by: Li Liu

Layout by: Li Liu

Printed by: Gildeprint proefschrift

**The unexplored functions of Toll-like receptor
signaling: Immunometabolism, development and
microbiome interactions**

Proefschrift

ter verkrijging van
de graad van doctor aan de Universiteit Leiden,
op gezag van rector magnificus prof.dr.S.de Rijcke,
volgens besluit van het college voor promoties
te verdedigen op dinsdag 17 maart 2026
klokke 16.00 uur

door

Li Liu

geboren te Liaoning, China

in 1996

Promotores:

Prof. Dr. H. P. Spaink
Prof. Dr. R. M. H. Merks

Promotiecommissie:

Prof. Dr. A. H. Meijer
Prof. Dr. B. E. Snaar-Jagalska
Prof. Dr. A. Alia
Dr. R. C. van Wijk
Prof. Dr. J. F. Rawls (Duke University)
Dr. S. Brugman (Wageningen University)

Table of Contents

Chapter 1	General introduction.....	7
Chapter 2	Transcriptomic and metabolomic studies reveal that Toll-like receptor 2 controls metabolism in unchallenged zebrafish larvae.....	27
Chapter 3	Toll-like receptor adaptor protein TIRAP has specialized roles in signaling, metabolic control and leukocyte migration upon wounding in zebrafish larvae.....	55
Chapter 4	The function of Toll-like receptor 2 in control of transcriptome responses to the microbiome and microbiome composition.....	99
Chapter 5	The function of Toll-like receptor 2 and the microbiome in macrophage-dependent dissemination of nontuberculous mycobacterial gut infection.....	143
Chapter 6	Summarizing discussion.....	193
Appendices	Nederlandse samenvatting.....	211
	Curriculum vitae.....	225
	List of publications.....	226
	Acknowledgements.....	227