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A novel membrane protein insertion pathway in Escherichia coli

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**A novel membrane protein insertion
pathway in *Escherichia coli***

Dedicated to my grandfather Theodor Specht (1921-1996)

*“Nothing on earth stays forever,
but none of your deeds were in vain.
Deep in our hearts you will live again,
you’ve gone to the home of the brave”*

Joachim Cans (1997)

Cover: The thinker, clay sculpture by Sandra Kuiper (original by Auguste Rodin, 1882)

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RIJKSUNIVERSITEIT GRONINGEN

**A novel membrane protein insertion
pathway in *Escherichia coli***

Proefschrift

**ter verkrijging van het doctoraat in de
Wiskunde en Natuurwetenschappen
aan de Rijksuniversiteit Groningen
op gezag van de
Rector Magnificus, dr. F. Zwarts,
in het openbaar te verdedigen op
vrijdag 10 september 2004
om 14.45 uur**

door

Martin van der Laan

**geboren op 13 maart 1974
te Leer, Duitsland**

Promotor : Prof dr. A.J.M. Driessen

Copromotor : dr. N.P. Nouwen

Beoordelingscommissie: Prof. dr. B. Poolman

Prof. dr. L. Dijkhuizen

Prof. dr. B. Oudega

Preface

So finally, this little book is ready to be printed and I may look back on the four exciting years of my life that I spent in Groningen and worked in the Department of Molecular Microbiology at the Biological Centre in Haren. When I think about all the blood, sweat and tears, but also about the triumph and joy, the heart and the soul that lie hidden between all the following lines and pages, some great people come to my mind, who accompanied, supported and guided me on this long and winding road. I want you to know that I am very grateful to all of you and that I wish you good luck and success for the future. May all your dreams come true !

Arnold, my promotor, I would like to thank you for a very pleasant, instructive and scientifically productive time. It was the open-minded, creative and stimulating atmosphere that I experienced in your lab during my visit as a student back in 1998 that hooked my heart up on science. During my years as a PhD student, you always found an excellent balance between guidance and freedom. Your trust and confidence was a solid basis for me to develop as a scientist and as a person. You somehow always knew when to push me, when to comfort me, when to hold me back. You shared your experience and your enthusiasm with me and gave me the time and scope to grow.

Nico, my copromotor, your contribution to this thesis is immense. Your energy, your motivation, your ideas for new experiments and your critical view on my work were extremely important and helpful for me. I learned so many things from you, but above all the realistic interpretation of my own data. It was a pleasure to work with you in A252 and I thank you very much for everything !

Eli, my paranimf and lab mate, I really enjoyed working, cursing and laughing with you and I highly esteem your deep scientific insight and understanding. Your interest in “hardcore” biochemistry and my interest in cell biology complemented one another perfectly in approaching a problem together. And I apologize for calling your music “melody-free noise”... Rock on, dude !

Bastiaan and Dirk-Jan, my great friends, plain and simple words can hardly describe, what we share. Our discussions and brainstormings about science, about God and the

ways of the world, about politics and life in general, about music, literature and all the other things that make life a little bit more worth living, and last but not least about our love and our dreams were a wonderful and everflowing source of inspiration and motivation for me. You were with me in triumph and defeat, you suffered and exulted with me and you were always upright and honest. For me, you are two of the few real friends that a man meets in his life and I hope that we never lose contact... 'til death do us part !

Andreas, my brother in metal, I will never forget the long evenings (Should I say nights...?) we spent together with our good ol' friend Remy Martin (Remember his tasteless and boring little brother... ?) listening to the greatest music in the world and discussing about the four most important things in life: science, philosophy, love and heavy metal music !! I think we know a lot about each other, things we normally bury deep in our hearts. I wish you all the best on your future ways, wherever they may lead you. In union we stand to keep the fire burning !

My dear fellow Molmix, colleagues and friends, I would like to thank you for the excellent atmosphere in the lab, for all the discussions and the fun that we had together. You are too numerous to mention you all, but I would like to name a few, who have a special place in my memory and in my heart: Chris ("Deutsch sprechen macht Spaß."), Sonja (Thanks for the philosophic morning coffees and the chances to release some steam from my mental boiler every now and then!); Jeanine ("Sec in black" rules!), Jelto (my patient as wise first supervisor), Danka (The sunshine of our office), Janny (drill instructor with a heart of gold), Titia ("Gravity ?" – "Checked !"), Philipp (The JCB paper is your baby, thanks for working with me !), Ilja (our brave Don Quixote fighting the SPR wind mill...), Oscar (my isotopia labmate), Bea & Manon (the wonderful femmes fatales from the secretariate, who saved my nerves so many times) and Juke (always willing to discuss the wildest ideas and theories with me – thanks !).

During my time in Groningen, I also had the opportunity to work in the labs of Ben de Kruijff in Utrecht and Joen Luirink in Amsterdam. These fruitful cooperations resulted in several joint publications. For me, this was a very exciting and instructive experience and I would like to thank everybody, who was involved in these projects, especially Edith, Malene and Ronald from the VU. We had a perfect time together, scientifically as well as personally, and a lot of great fun ("Ga je mee, naar het ErEnCeeee....!").

Very special thanks also go out to you, Katja, for your true friendship and care, for all the exciting hours we spent together and for all the high quality lunches and dinners. And never ever forget: Cats don't belong on the table – at least not during the meals !

Einen ganz besonders herzlichen und warmen Dank möchte ich einigen lieben Menschen aussprechen, die mich schon seit so vielen Jahren mit ihrer Unterstützung und Liebe durch mein Leben begleiten.

Meine Eltern, Gerda und Dirk, ich danke Euch für Euer Vertrauen, für Eure Hilfsbereitschaft und dafür, dass Ihr mir die Zuversicht gebt, dass ich mich immer auf Euch verlassen kann. Es springt sich leichter in einen neues Abenteuer, wenn man weiss, dass da jemand ein Netz unter einem aufgespannt hat.

Thomas, mein kleiner großer Bruder, ich danke Dir für zahllose wichtige und gute Gespräche, für Deinen exzellenten Musikgeschmack und für die Herzlichkeit und Zuneigung, mit der Du mir begegnest. Du wirst Deinen Weg machen, da bin ich mir ganz sicher. Zeig's Ihnen !

Meike, meine beste Freundin, ich bin beinahe geneigt zu schreiben, meine große Schwester, die ich nie hatte. Unsere Freundschaft hat nun schon fast zwanzig Jahre überdauert und ich möchte Dir ganz herzlich dafür danken, dass es Dich gibt, und dass Du in all den Jahren trotz großer räumlicher Distanz den Kontakt zu mir immer wieder gesucht hast. Du bist ein wunderbarer und überaus wertvoller Mensch !

Bis zum Ende habe ich mir den wichtigsten Menschen in meinem Leben aufgespart. Sandra, meiner kleiner Tiger, ich danke Dir sehr für Deine Wärme und Liebe, für Deine Unterstützung und Dein Verständnis, für Deine verrückten Ideen und dafür, dass Du tatsächlich mit mir Chaot alt werden willst. Ich liebe Dich !

Euer Martin

Kirchzaren, 11.07.2004

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