



**Strategic workshops**  
***'Intrinsic Mechanisms in Chronic Disease'***  
***'Extrinsic Mechanisms in Chronic Disease'***  
***'Therapy and Prevention – Emerging Concepts'***

19-22 October 2010  
Princesa Sofia Gran Hotel, Barcelona, Spain

## **Management of the Forward Look**

### **Scientific Committee**

#### **Co-Chairs**

Dirk Haller, *Technical University Munich, Germany*

Harald Renz, *Philipps-University Marburg, Germany*

#### **Members**

Ingo B. Autenrieth, *Universitätsklinikum Tübingen, Germany*

Per Brandtzaeg, *Oslo University Hospital, Norway*

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Rudolf Valenta, *Universität Wien, Austria*

Erika von Mutius, *Dr. von Hauner Children's Hospital, Ludwig-Maximilians University Munich, Germany*

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### **Administrative Support**

Iain Patten, *Medical Writer, Valencia, Spain*

### **ESF Staff**

Stephane Berghmans, *Head of Medical Sciences Unit, ESF, France*

Nathalie Spielewoy, *Junior Science Officer, ESF, France*

## **EMRC Forward Look 'Gene Environment Interaction in Chronic Disease'**

Following discussion with Professor Martin Röllinghoff, EMRC Standing Committee member, this Forward Look proposal was written by Professor Harald Renz and Professor Dirk Haller. It was endorsed for funding by the ESF Science Advisory Board and approved by the Governing Council in October 2009.

The activity was launched on 20 January 2010 by a Kick-off Meeting with the Scientific Committee at the Technical University, Munich, Germany. There three Strategic Workshops were decided to take place from 19 to 22 October 2010. International scientific experts in the field were invited to attend those closed events and contribute to the foresight exercise aiming to set priorities/recommendations and assess impacts and chances to tackle chronic disease.

During the Strategic Workshops, the participants will be asked to define the influencing fields, the descriptors and polarities in the field of chronic disease. The influencing fields can be described as the main actors, the descriptors are consequently the 2<sup>nd</sup> roles and the polarities are the possible directions of descriptors. With those information collected, Scenarios will be built to describe possible future developments, and identify the most desired scenarios. It is expected that the exercise will reveal underlying assumptions, structure the field and identify decision points. To reach the most desired scenarios, relevant drivers will be identified and strategies will be developed.

## Introduction

The dramatic increase of chronic inflammatory and degenerative diseases particularly in the industrialized world implies a complex interaction of host genetic predispositions and environmental triggers. The European Science Foundation initiated a “Forward Look” initiative with world leading experts in Barcelona to discuss the dynamic interactions of disease susceptible genomes with an enormously complex environment in order to develop novel research strategies for the prevention and therapeutic intervention of lifestyle-related chronic diseases including chronic inflammatory disorders of the gastro-intestinal tract and airways as well as neurodegenerative and metabolic pathologies.

Recently a great advancement has been achieved in the understanding of the complex immunological signalling cascades which drive chronic inflammation. The cellular and molecular interaction between the innate and the adaptive immune system results in the generation of specialised T-helper cell populations which control many of the downstream effector responses. Prominent examples are Th-1 and Th-17 cells which play a dominant role in chronic inflammatory bowel disease, type-1 diabetes (T1DM) and in multiple sclerosis, respectively. In contrast, Th-2 T-cells are important regulators in allergic diseases of the lung skin and gut. Although it is well established that certain polymorphisms in an increasing number of genes predispose for disease development, the dramatic increase in prevalence and incidence of these conditions within a relatively short timeframe points towards environmental factors which trigger disease development.

Nutrition-related factors together with components of the mucosa-associated microbial ecosystem (gut, lung, uro-genital tract) emerged as prime environmental triggers for the development and modification for the development of metabolically-driven and inflammation-mediated pathologies. Recent discoveries clearly suggest that the gut and lung associated microbiota of individuals throughout their lifespan is a powerful determinant of chronic diseases, and that the mechanisms underlying this link involve the development of inflammatory activity in the organ-specific mucosa. Nutritional factors and/or the metabolic status of the host clearly contribute to the disease susceptibility either through direct mechanisms or indirectly through the modulation of the gut microbial ecology.

It has been proposed to complement the search for disease susceptibility genes in the human genome with the analysis of the gut “microbiome”, considering the hypothesis that health or disease is being determined by the complex interaction of the host with its gut microbial ecosystem. Since the pioneering work by Louis Pasteur and Robert Koch in the 19th century, the study of pathogens has been a major interest in the field of infectious disease. Yet, over the last years, advances in the understanding of the gut microbial ecology have highlighted the fundamental role of commensal gut microbes in human health and disease. The hygiene hypothesis provides a challenging concept for the explanation of increases in chronic inflammatory diseases. Striking evidence is provided for the role of the intestinal and lung associated microbiota in the pathogenesis of inflammatory bowel diseases and asthma. In addition, the intestinal microbiota affects fat storage, as well as the development of autoimmune T1DM and experimental T2DM through gut- and liver-derived mechanisms linking bacterial signals from the gut microbiota with inflammatory processes and altered lipid metabolism. Interestingly, these gut- and metabolic-associated diseases share common traits in their cellular pathogenesis, suggesting a link between inflammatory processes, pattern recognition receptors and highly conserved cellular stress response pathways of the endoplasmic reticulum (ER).

Recent evidence supports the concept that host-environment interactions operate during certain “windows of opportunity” in life in order to develop and maintain clinical and immunological tolerance. Fetal life has been identified as one of such windows where education and training of the immune system already starts. Epigenetic regulation represents one important level of gene-environment interaction which represents a further rapidly evolving research field.

These and other findings support the hypothesis that the intestinal microbiota is an essential part of a disease-conditioning environment harbouring the capability to drive the development of chronic pathologies in the genetically susceptible host. This Forward Look Initiative on “Gene-environment interactions in chronic diseases” of the European Science Foundation provides an interdisciplinary effort in implementing basic science, genetics, and clinical disciplines such as gastroenterology, medical microbiology and immunology, and nutritional medicine targeting fundamental mechanisms of host-microbe interactions in order to guide novel concepts for diagnostic, primary prevention and treatment of immune-mediated and/or chronic inflammatory diseases.

**Dirk Haller and Harald Renz**

## Workshop 1 'Intrinsic Mechanisms in Chronic Disease'

**Chair** Dirk Haller, *Technical University Munich, Germany*  
**Co- Chair** Per Brandtzæg, *Oslo University Hospital, Norway*

Tuesday 19 October 2010

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13:00 Registration and Lunch

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14:00 **ESF Introduction**  
Nathalie Spielowoy, Stephane Berghmans, *European Science Foundation, Strasbourg, France*

**Welcome and Introductory Remarks**  
Dirk Haller, *Technical University Munich, Germany*

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### Session 1: Genetic Susceptibility

#### **Nutrient-gene interaction**

##### *Keynote Speaker*

Michael Müller, *Division of Human Nutrition, Wageningen University, The Netherlands*

#### **Allergy and asthma**

Francine Kauffmann, *Epidemiology and Statistics, INSERM, Villejuif, France*

#### **Gene environment interactions underlying type I diabetes**

Jayne Danska, *The Hospital for Sick Children, Toronto, Canada*

#### **Neurodegenerative diseases**

Hartmut Wekerle, *Max-Planck-Institute of Neurobiology, Martinsried, Germany*

#### **Metabolic diseases**

Hans-Georg Joost, *German Institute of Human Nutrition (DIfE), Potsdam-Rehbrücke, Germany*

#### **Environment and epigenetic imprinting**

Bastiaan T. Heijmans, *Leiden University Medical Centre, The Netherlands*

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17.00-17.30 **Coffee Break**

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### 17.30 Session 2: Immune-Mediated Pathogenesis

#### **Gut-associated immune responses**

Oliver Pabst, *Institute of Immunology, Hannover Medical School, Germany*

#### **Lung-associated immune responses**

Martinus Lovik, *National Institute of Public Health (NIPH Folkehelsa), Oslo, Norway*

#### **Epithelial cells and barrier function**

Donna Davies, *Faculty of Medicine and Health and Life Sciences, University of Southampton, United Kingdom*,  
(apologies, presentation by Dr Emily Swindle)

#### **Epithelial cells, TLRs, microbiota and tolerance**

Mathias Hornef, *Institute for Medical Microbiology and Hospital Epidemiology, Hannover Medical School, Germany*

#### **NK cells in tolerance and immunity**

Andreas Diefenbach, *Institute of Medical Microbiology & Hygiene, University of Freiburg, Germany*

#### **Mast cells at tissue interface**

Stephan Bischoff, *Institute of Nutritional Medicine, University of Hohenheim, Stuttgart, Germany*

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20:30 Dinner

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Wednesday 20 October 2010

8.30 **Session 3: Mechanism of Inflammation**

**ER stress and autophagy**

*Keynote Speaker*

Richard Blumberg, *Brigham and Women's Hospital, Harvard Medical School, Boston, United States*

**Update on genetics of inflammatory bowel disease**

Jean-Pierre Hugot, *Hôpital Robert Debré, INSERM U843, Paris, France*

**The gut-brain axis**

John Bienenstock, *The Brain-Body Institute, St. Joseph's Healthcare Hamilton, Canada*

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10.00-10.30 **Coffee Break**

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**Phenotype and function of intestinal dendritic cells and macrophages**

Lesley E Smythies, *University of Alabama, Birmingham, United States*

**Epigenetics at the crossroads of T-helper lineage commitment**

Ola Winqvist, *Karolinska Institute, Karolinska University Hospital, Stockholm, Sweden*

**B cell responses**

Nicola L. Harris, *Ecole Polytechnique Fédérale de Lausanne, Switzerland*

**NF- $\kappa$ B in acute and chronic inflammation**

Manolis Pasparakis, *Institute for Genetics, University of Cologne, Germany*

**Strategic Discussion**

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12:30 Closing and Lunch

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## Workshop 2 'Extrinsic Mechanisms in Chronic Disease'

**Chair** Erika von Mutius, *Dr. von Hauner Children's Hospital, Ludwig-Maximilians University Munich, Germany*  
**Co- Chair** Ingo B. Autenrieth, *Universitätsklinikum Tübingen, Germany*

Wednesday 20 October 2010

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13:00 Registration and Lunch

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14:00 **ESF Introduction**  
Nathalie Spielowoy, Stephane Berghmans, *European Science Foundation, Strasbourg, France*

**Welcome and Introductory Remarks**  
Erika von Mutius, *Pediatric Allergology/Pneumology, Munich, Germany*

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### Session 1: Microbe-Host Interactions

#### Microbiota of surfaces and disease

##### *Keynote Speaker*

Rob Knight, *University of Colorado at Boulder, United States*

#### Gut microbiome and health

Dusko Ehrlich, *Microbiology and Food Chain (MICA), INRA, Jouy-en-Josas, France*

#### How can we characterise human gut microbiota and what variability do we see?

Harry Flint, *Rowett Institute of Nutrition and Health, University of Aberdeen, United Kingdom*

#### Host gut microbiota interactions

Helena Tlaskalova-Hogenova, *Institute of Microbiology of the Academy of Sciences of the Czech Republic, Prague, Czech Republic*

#### Local and systemic immune effects of host commensal interactions in the gut

Valerie Gaboriau-Routhiau, *INRA/INSERM, U910, Jouy-en-Josas, France*

#### Importance of skin microbes for immune maturation

Agnes Wold, *Institute of Biomedicine, University of Gothenburg, Sweden*

#### Strategic Discussion

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17.00-17.30 **Coffee Break**

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### Session 2: Mechanisms of Microbe-host Interactions: Defining the Targets

#### Dendritic cell-microbe interactions

##### *Keynote Speaker*

Bart Lambrecht, *Faculty of Medicine and Health Sciences, Ghent University, Belgium*

#### Airways microbiota in health and disease

William O. Cookson, *Imperial College London, United Kingdom*

#### Environmental microbial exposures

Dick Heederik, *Institute of Risk Assessment Sciences, University of Utrecht, The Netherlands*

#### Interactions between microbes and the innate immune system

Denise Kelly, *Rowett Institute of Nutrition and Health, University of Aberdeen, United Kingdom*

#### Strategic Discussion

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20:30 Dinner

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Thursday 21 October 2010

**8:30 Session 3: Intervention Strategies for Microbe-Host Interactions**

**Genetic polymorphisms promoting inflammation in a complex environment - novel strategies for therapy and intervention**

**Keynote Speaker**

Stefan Schreiber, *Institute for Clinical Molecular Biology, Christian-Albrechts-University, Kiel, Germany*

**Microbiota and lactobazilli**

Michiel Kleerebezem, *NIZO Food Research, Wageningen University, The Netherlands*

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**10.00-10.30 Coffee Break**

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**Dietary factors in chronic disease**

Heiner Boeing, *German Institute of Human Nutrition (DIfE), Berghol-Rehbrücke, Germany*

**Probiotics and allergies**

Erika Isolauri, *Department of Paediatrics, University of Turku, Finland*, (apologies, presentation by Seppo Salminen)

**Recombinant lactobacteria**

Jerry M Wells, *Faculty of Animal Sciences, University of Wageningen, The Netherlands*

**Strategic Discussion**

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**12:30 Closing and Lunch**

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## Workshop 3 'Therapy and Prevention – Emerging Concepts'

**Chair** Harald Renz, *Philipps-University Marburg, Germany*  
**Co- Chair** William O. Cookson, *Imperial College London, United Kingdom*

Thursday 21 October 2010

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13:00 Registration and Lunch

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14:00 **ESF Introduction**  
Nathalie Spielewoy, Stephane Berghmans, *European Science Foundation, Strasbourg, France*

**Welcome and Introductory Remarks**  
Harald Renz, *Philipps-University Marburg, Germany*

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### Session 1: Tolerance Induction - Preclinical/Clinical Studies

#### Inflammatory Bowel Disease

##### *Keynote Speaker*

Markus Neurath, *Department of Medicine, University of Erlangen-Nürnberg, Germany*

#### Pediatric allergy (excluding asthma)

Jürgen Schwarze, *Queens Medical Research Institute, University of Edinburgh, United Kingdom*

#### Asthma in childhood

Hans Bisgaard, *Faculty of Health Science, Copenhagen University, Denmark*

#### Protection from childhood asthma and allergies in rural environments

Charlotte Braun-Fahrlander, *Institute of Social and Preventive Medicine, University of Basel, Switzerland*

#### Strategic Discussion

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17.00-17.30 **Coffee Break**

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### Session 2: Therapeutic Intervention

#### New targets for asthma therapy

##### *Keynote Speaker*

Stephen Holgate, *Southampton General Hospital, United Kingdom*

#### Hypo-allergenic molecules and specific immunotherapy

Ursula Wiedermann, *Institute of Specific Prophylaxis and Tropical Medicine, Medical University of Vienna, Austria*

#### Antisense technologies

Joerg Vogel, *Institute of Molecular Infection Biology, University of Würzburg, Germany*

#### Strategic Discussion

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20:30 Dinner

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Friday 22 October 2010

### Session 3: Prevention

#### Metabolic imprinting of chronic inflammatory disease

##### *Keynote Speaker*

Berthold Koletzko, *Dr. von Hauner Children's Hospital, Ludwig-Maximilians University, Munich, Germany*

#### Probiotics in allergy

Matthias Kopp, *Klinik für Kinder- und Jugendmedizin, Universitätsklinikum Schleswig-Holstein, Germany, (apologies, presentation by Markus Weckmann)*



**Probiotics in IBD and other diseases**

Francisco Guarner, *University Hospital Vall d'Hebron, Barcelona, Spain*

**Genetically modified probiotics**

Lothar Steidler, *ActoGeniX NV, Zwijnaarde, Belgium*

**Other bacterial /microbial preparations**

Seppo Salminen, *Functional Foods Forum, University of Turku, Finland*

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10.00-10.30      **Coffee Break**

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**Hypoallergenic milk**

Sibylle Koletzko, *Dr. von Hauner Children's Hospital, Ludwig-Maximilians University, Munich, Germany*

**Methyl-rich diets / supplements (folic acid, B12, cholin, etc.)**

John Hollingsworth, *Duke University Medical Centre, Durham, United States*

**Antioxidant supplements and allergen avoidance**

Graham Devereux, *Applied Health Sciences, University of Aberdeen, United Kingdom*

**Strategic Discussion**

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12:30      Closing and Lunch

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## Selection of reviews

### Workshop 1 'Intrinsic Mechanisms in Chronic Disease'

#### Session 1: Genetic Susceptibility

**Michael Müller**, *Division of Human Nutrition, Wageningen University, The Netherlands*

- Kersten, S. Regulation of nutrient metabolism and inflammation. *Results Probl Cell Differ* **52**, 13-25 (2010).
- Müller, M. & Kersten, S. Nutrigenomics: goals and strategies. *Nat. Rev. Genet* **4**, 315-322 (2003).
- Nathan, C. & Ding, A. Nonresolving inflammation. *Cell* **140**, 871-882 (2010).

**Francine Kauffmann**, *Epidemiology and Statistics, INSERM, Villejuif, France*

- Kauffmann, F., Castro-Giner, F., Smit, L.A.M., Nadif, R. & Kogenivas, M. Gene-environment interactions in occupational asthma. *Occupational Asthma* 205-228 (2010).
- Vercelli, D. Gene-environment interactions in asthma and allergy: the end of the beginning? *Curr Opin Allergy Clin Immunol* **10**, 145-148 (2010).
- Meyers, D.A. Genetics of asthma and allergy: what have we learned? *J. Allergy Clin. Immunol* **126**, 439-446; quiz 447-448 (2010).

**Jayne Danska**, *The Hospital for Sick Children, Toronto, Canada*

- Okada, H., Kuhn, C., Feillet, H. & Bach, J. The 'hygiene hypothesis' for autoimmune and allergic diseases: an update. *Clin. Exp. Immunol* **160**, 1-9 (2010).
- Todd, J.A. Etiology of type 1 diabetes. *Immunity* **32**, 457-467 (2010).
- Ziegler, A. & Nepom, G.T. Prediction and pathogenesis in type 1 diabetes. *Immunity* **32**, 468-478 (2010).

**Hartmut Wekerle**, *Max-Planck-Institute of Neurobiology, Martinsried, Germany*

- Wekerle, H. & Kurschus, F.C. Animals models of multiple sclerosis. *Drug Discovery Today: Disease Models* **3**, 359-367 (2005).
- Round, J.L. & Mazmanian, S.K. The gut microbiota shapes intestinal immune responses during health and disease. *Nat. Rev. Immunol* **9**, 313-323 (2009).
- Chervonsky, A.V. Influence of microbial environment on autoimmunity. *Nat. Immunol* **11**, 28-35 (2010).

**Hans-Georg Joost**, *German Institute of Human Nutrition (DIfE), Potsdam-Rehbrücke, Germany*

- Joost, H. Pathogenesis, risk assessment and prevention of type 2 diabetes mellitus. *Obes Facts* **1**, 128-137 (2008).
- O'Rahilly, S. Human genetics illuminates the paths to metabolic disease. *Nature* **462**, 307-314 (2009).
- Szendroedi, J. & Roden, M. Mitochondrial fitness and insulin sensitivity in humans. *Diabetologia* **51**, 2155-2167 (2008).

**Bastiaan T. Heijmans**, *Leiden University Medical Centre, The Netherlands*

- Stöger, R. The thrifty epigenotype: an acquired and heritable predisposition for obesity and diabetes? *Bioessays* **30**, 156-166 (2008).
- Waterland, R.A. & Michels, K.B. Epigenetic epidemiology of the developmental origins hypothesis. *Annu. Rev. Nutr* **27**, 363-388 (2007).
- Heijmans, B.T., Tobi, E.W., Lumey, L.H. & Slagboom, P.E. The epigenome: archive of the prenatal environment. *Epigenetics* **4**, 526-531 (2009).

#### Session 2: Immune-Mediated Pathogenesis

**Oliver Pabst**, *Institute of Immunology, Hannover Medical School, Germany*

- Iwata, M. Retinoic acid production by intestinal dendritic cells and its role in T-cell trafficking. *Semin. Immunol* **21**, 8-13 (2009).
- Barnes, M.J. & Powrie, F. Regulatory T cells reinforce intestinal homeostasis. *Immunity* **31**, 401-411 (2009).
- Agace, W. Generation of gut-homing T cells and their localization to the small intestinal mucosa. *Immunol. Lett* **128**, 21-23 (2010).

**Martinus Lovik**, *National Institute of Public Health (NIPH Folkehelse), Oslo, Norway*

- Kim, H.Y., DeKruyff, R.H. & Umetsu, D.T. The many paths to asthma: phenotype shaped by innate and adaptive immunity. *Nat. Immunol* **11**, 577-584 (2010).
- Cosio, M.G., Saetta, M. & Agusti, A. Immunologic aspects of chronic obstructive pulmonary disease. *N. Engl. J. Med* **360**, 2445-2454 (2009).
- Garantziotis, S. & Schwartz, D.A. Ecogenomics of respiratory diseases of public health significance. *Annu Rev Public Health* **31**, 37-51 1 p following 51 (2010).

**Donna Davies**, *Faculty of Medicine and Health and Life Sciences, University of Southampton, United Kingdom*

- Marchiando, A.M., Graham, W.V. & Turner, J.R. Epithelial barriers in homeostasis and disease. *Annu Rev Pathol* **5**, 119-144 (2010).
- Hammad, H. & Lambrecht, B.N. Dendritic cells and epithelial cells: linking innate and adaptive immunity in asthma. *Nat. Rev. Immunol* **8**, 193-204 (2008).
- Swindle, E.J., Collins, J.E. & Davies, D.E. Breakdown in epithelial barrier function in patients with asthma: identification of novel therapeutic approaches. *J. Allergy Clin. Immunol* **124**, 23-34; quiz 35-36 (2009).

**Mathias Hornef**, *Institute for Medical Microbiology and Hospital Epidemiology, Hannover Medical School, Germany*

- Garrett, W.S., Gordon, J.I. & Glimcher, L.H. Homeostasis and inflammation in the intestine. *Cell* **140**, 859-870 (2010).
- Kawai, T. & Akira, S. The role of pattern-recognition receptors in innate immunity: update on Toll-like receptors. *Nat. Immunol* **11**, 373-384 (2010).
- O'Neill, L.A.J. When signaling pathways collide: positive and negative regulation of toll-like receptor signal transduction. *Immunity* **29**, 12-20 (2008).

**Andreas Diefenbach**, *Institute of Medical Microbiology & Hygiene, University of Freiburg, Germany*

- Diefenbach, A. & Vonarbourg, C. Innate lymphocytes induce inflammatory bowel disease. *Immunol Cell Biol* (2010).doi:10.1038/icb.2010.82
- Cooper, M.A., Colonna, M. & Yokoyama, W.M. Hidden talents of natural killers: NK cells in innate and adaptive immunity. *EMBO Rep* **10**, 1103-1110 (2009).
- Vivier, E., Spits, H. & Cupedo, T. Interleukin-22-producing innate immune cells: new players in mucosal immunity and tissue repair? *Nat. Rev. Immunol* **9**, 229-234 (2009).

**Stephan Bischoff**, *Institute of Nutritional Medicine, University of Hohenheim, Stuttgart, Germany*

- Abraham, S.N. & St John, A.L. Mast cell-orchestrated immunity to pathogens. *Nat. Rev. Immunol* **10**, 440-452 (2010).
- Bischoff, S.C. Role of mast cells in allergic and non-allergic immune responses: comparison of human and murine data. *Nat. Rev. Immunol* **7**, 93-104 (2007).
- Kalesnikoff, J. & Galli, S.J. New developments in mast cell biology. *Nat. Immunol* **9**, 1215-1223 (2008).

### Session 3: Mechanism of Inflammation

**Richard Blumberg**, *Brigham and Women's Hospital, Harvard Medical School, Boston, United States*

- Kaser, A., Zeissig, S. & Blumberg, R.S. Inflammatory bowel disease. *Annu. Rev. Immunol* **28**, 573-621 (2010).
- Kaser, A., Martínez-Naves, E. & Blumberg, R.S. Endoplasmic reticulum stress: implications for inflammatory bowel disease pathogenesis. *Curr. Opin. Gastroenterol* **26**, 318-326 (2010).
- Kaser, A. & Blumberg, R.S. Endoplasmic reticulum stress and intestinal inflammation. *Mucosal Immunol* **3**, 11-16 (2010).

**Jean-Pierre Hugot**, *Hôpital Robert Debré, INSERM U843, Paris, France*

- Cho, J.H. The genetics and immunopathogenesis of inflammatory bowel disease. *Nat. Rev. Immunol* **8**, 458-466 (2008).
- Hunter, D.J. Gene-environment interactions in human diseases. *Nat. Rev. Genet* **6**, 287-298 (2005).
- Pineton de Chambrun, G., Colombel, J., Poulain, D. & Darfeuille-Michaud, A. Pathogenic agents in inflammatory bowel diseases. *Curr. Opin. Gastroenterol* **24**, 440-447 (2008).

**John Bienenstock**, *The Brain-Body Institute, St. Joseph's Healthcare Hamilton, Canada:*

- Collins, S.M. & Bercik, P. The relationship between intestinal microbiota and the central nervous system in normal gastrointestinal function and disease. *Gastroenterology* **136**, 2003-2014 (2009).
- Forsythe, P., Sudo, N., Dinan, T., Taylor, V.H. & Bienenstock, J. Mood and gut feelings. *Brain Behav. Immun* **24**, 9-16 (2010).
- Freestone, P.P.E., Sandrini, S.M., Haigh, R.D. & Lyte, M. Microbial endocrinology: how stress influences susceptibility to infection. *Trends Microbiol* **16**, 55-64 (2008).

**Lesley E Smythies**, *University of Alabama, Birmingham, United States*

- Kelsall, B. Recent progress in understanding the phenotype and function of intestinal dendritic cells and macrophages. *Mucosal Immunol* **1**, 460-469 (2008).
- Platt, A.M. & Mowat, A.M. Mucosal macrophages and the regulation of immune responses in the intestine. *Immunol. Lett* **119**, 22-31 (2008).
- Rescigno, M. & Di Sabatino, A. Dendritic cells in intestinal homeostasis and disease. *J. Clin. Invest* **119**, 2441-2450 (2009).

**Ola Winqvist**, *Karolinska Institute, Karolinska University Hospital, Stockholm, Sweden*

- Huehn, J., Polansky, J.K. & Hamann, A. Epigenetic control of FOXP3 expression: the key to a stable regulatory T-cell lineage? *Nat. Rev. Immunol* **9**, 83-89 (2009).

- Wilson, C.B., Rowell, E. & Sekimata, M. Epigenetic control of T-helper-cell differentiation. *Nat. Rev. Immunol* **9**, 91-105 (2009).
- Janson, P.C.J., Winerdal, M.E. & Winqvist, O. At the crossroads of T helper lineage commitment-Epigenetics points the way. *Biochim. Biophys. Acta* **1790**, 906-919 (2009).

**Nicola L. Harris**, *Ecole Polytechnique Fédérale de Lausanne, Switzerland*

- Brandtzaeg, P. Update on mucosal immunoglobulin A in gastrointestinal disease. *Curr Opin Gastroenterol* (2010).doi:10.1097/MOG.0b013e32833dccc8
- Lund, F.E. & Randall, T.D. Effector and regulatory B cells: modulators of CD4(+) T cell immunity. *Nat. Rev. Immunol* **10**, 236-247 (2010).
- Fillatreau, S., Gray, D. & Anderton, S.M. Not always the bad guys: B cells as regulators of autoimmune pathology. *Nat. Rev. Immunol* **8**, 391-397 (2008).

**Manolis Pasparakis**, *Institute for Genetics, University of Cologne, Germany*

- Ghosh, S. & Hayden, M.S. New regulators of NF-kappaB in inflammation. *Nat. Rev. Immunol* **8**, 837-848 (2008).
- Grivannikov, S.I., Greten, F.R. & Karin, M. Immunity, inflammation, and cancer. *Cell* **140**, 883-899 (2010).
- Pasparakis, M. Regulation of tissue homeostasis by NF-kappaB signalling: implications for inflammatory diseases. *Nat. Rev. Immunol* **9**, 778-788 (2009)

## Workshop 2 'Extrinsic Mechanisms in Chronic Disease'

### Session 1: Microbe-Host Interactions

**Rob Knight**, *University of Colorado at Boulder, United States*

- Hamady, M. & Knight, R. Microbial community profiling for human microbiome projects: Tools, techniques, and challenges. *Genome Res* **19**, 1141-1152 (2009).
- Kuczynski, J. et al. Direct sequencing of the human microbiome readily reveals community differences. *Genome Biol* **11**, 210 (2010).
- Ley, R.E., Lozupone, C.A., Hamady, M., Knight, R. & Gordon, J.I. Worlds within worlds: evolution of the vertebrate gut microbiota. *Nat. Rev. Microbiol* **6**, 776-788 (2008).

**Dusko Ehrlich**, *Microbiology and Food Chain (MICA), INRA, Jouy-en-Josas, France*

- Ehrlich, S.D. & MetaHIT consortium Metagenomics of the intestinal microbiota: potential applications. *Gastroenterologie Clinique et Biologique* (2010).
- Carroll, I.M., Threadgill, D.W. & Threadgill, D.S. The gastrointestinal microbiome: a malleable, third genome of mammals. *Mamm. Genome* **20**, 395-403 (2009).
- Qin, J. et al. A human gut microbial gene catalogue established by metagenomic sequencing. *Nature* **464**, 59-65 (2010).

**Harry Flint**, *Rowett Institute of Nutrition and Health, University of Aberdeen, United Kingdom*

- Zoetendal, E.G., Rajlic-Stojanovic, M. & de Vos, W.M. High-throughput diversity and functionality analysis of the gastrointestinal tract microbiota. *Gut* **57**, 1605-1615 (2008).
- Flint, H.J., Duncan, S.H., Scott, K.P. & Louis, P. Interactions and competition within the microbial community of the human colon: links between diet and health. *Environ. Microbiol* **9**, 1101-1111 (2007).
- Vrieze, A. et al. The environment within: how gut microbiota may influence metabolism and body composition. *Diabetologia* **53**, 606-613 (2010).

**Helena Tlaskalova-Hogenova**, *Institute of Microbiology of the Academy of Sciences of the Czech Republic, Prague, Czech Republic*

- Bäckhed, F., Ley, R.E., Sonnenburg, J.L., Peterson, D.A. & Gordon, J.I. Host-bacterial mutualism in the human intestine. *Science* **307**, 1915-1920 (2005).
- Tlaskalová-Hogenová, H. et al. Commensal bacteria (normal microflora), mucosal immunity and chronic inflammatory and autoimmune diseases. *Immunol. Lett* **93**, 97-108 (2004).
- Abt, M.C. & Artis, D. The intestinal microbiota in health and disease: the influence of microbial products on immune cell homeostasis. *Curr. Opin. Gastroenterol* **25**, 496-502 (2009).

**Valerie Gaboriau-Routhiau**, *INRA/INSERM, U910, Jouy-en-Josas, France*

- Cerf-Bensussan, N. & Gaboriau-Routhiau, V. The immune system and the gut microbiota: friends or foes? *Nat. Rev. Immunol* **10**, 735-744 (2010).
- Hooper, L.V. & Macpherson, A.J. Immune adaptations that maintain homeostasis with the intestinal microbiota. *Nat. Rev. Immunol* **10**, 159-169 (2010).
- Round, J.L. & Mazmanian, S.K. The gut microbiota shapes intestinal immune responses during health and disease. *Nat. Rev. Immunol* **9**, 313-323 (2009).

**Agnes Wold**, *Institute of Biomedicine, University of Gothenburg, Sweden*

- von Boehmer, H. Oral tolerance: is it all retinoic acid? *J. Exp. Med* **204**, 1737-1739 (2007).
- Kretschmer, K., Apostolou, I., Verginis, P. & von Boehmer, H. Regulatory T cells and antigen-specific tolerance. *Chem Immunol Allergy* **94**, 8-15 (2008).
- Cebra, J.J. Influences of microbiota on intestinal immune system development. *Am. J. Clin. Nutr* **69**, 1046S-1051S (1999).
- Adlerberth, I. & Wold, A.E. Establishment of the gut microbiota in Western infants. *Acta Paediatr* **98**, 229-238 (2009).

## Session 2: Mechanisms of Microbe-host Interactions: Defining the Targets

**Dick Heederik**, *Institute of Risk Assessment Sciences, University of Utrecht, The Netherlands*

- Simpson, A. & Martinez, F.D. The role of lipopolysaccharide in the development of atopy in humans. *Clin. Exp. Allergy* **40**, 209-223 (2010).
- Douwes, J., Brooks, C. & Pearce, N. Protective effects of farming on allergies and asthma: have we learnt anything since 1873? *Expert Rev Clin Immunol* **5**, 213-219 (2009).
- Korthals, M., Ege, M.J., Tebbe, C.C., von Mutius, E. & Bauer, J. Application of PCR-SSCP for molecular epidemiological studies on the exposure of farm children to bacteria in environmental dust. *J. Microbiol. Methods* **73**, 49-56 (2008).

**Denise Kelly**, *Rowett Institute of Nutrition and Health, University of Aberdeen, United Kingdom*

- Kelly, D., Conway, S. & Aminov, R. Commensal gut bacteria: mechanisms of immune modulation. *Trends Immunol* **26**, 326-333 (2005).
- Reiff, C. et al. Balancing inflammatory, lipid, and xenobiotic signaling pathways by VSL#3, a biotherapeutic agent, in the treatment of inflammatory bowel disease. *Inflamm. Bowel Dis* **15**, 1721-1736 (2009).
- Reiff, C. & Kelly, D. Inflammatory bowel disease, gut bacteria and probiotic therapy. *Int. J. Med. Microbiol* **300**, 25-33 (2010).

## Session 3: Intervention Strategies for Microbe-Host Interactions

**Michiel Kleerebezem**, *NIZO Food Research, Wageningen University, The Netherlands*

- Kleerebezem, M. & Vaughan, E.E. Probiotic and gut lactobacilli and bifidobacteria: molecular approaches to study diversity and activity. *Annu. Rev. Microbiol* **63**, 269-290 (2009).
- Zoetendal, E.G., Rajilic-Stojanovic, M. & de Vos, W.M. High-throughput diversity and functionality analysis of the gastrointestinal tract microbiota. *Gut* **57**, 1605-1615 (2008).
- Booijink, C.C.G.M., Zoetendal, E.G., Kleerebezem, M. & de Vos, W.M. Microbial communities in the human small intestine: coupling diversity to metagenomics. *Future Microbiol* **2**, 285-295 (2007).

**Heiner Boeing**, *German Institute of Human Nutrition (DIfE), Berghol-Rehbrücke, Germany*

- Illner, A., Nöthlings, U., Wagner, K., Ward, H. & Boeing, H. The assessment of individual usual food intake in large-scale prospective studies. *Ann. Nutr. Metab* **56**, 99-105 (2010).
- Ford, E.S. et al. Healthy living is the best revenge: findings from the European Prospective Investigation Into Cancer and Nutrition-Potsdam study. *Arch. Intern. Med* **169**, 1355-1362 (2009).
- Brennan, P. et al. Obesity and cancer: Mendelian randomization approach utilizing the FTO genotype. *Int J Epidemiol* **38**, 971-975 (2009).

**Erika Isolauri**, *Department of Paediatrics, University of Turku, Finland*

- Isolauri, E., Sütas, Y., Kankaanpää, P., Arvilommi, H. & Salminen, S. Probiotics: effects on immunity. *Am. J. Clin. Nutr* **73**, 444S-450S (2001).
- Isolauri, E., Rautava, S., Kalliomäki, M., Kirjavainen, P. & Salminen, S. Role of probiotics in food hypersensitivity. *Curr Opin Allergy Clin Immunol* **2**, 263-271 (2002).
- Isolauri, E., Kalliomäki, M., Laitinen, K. & Salminen, S. Modulation of the maturing gut barrier and microbiota: a novel target in allergic disease. *Curr. Pharm. Des* **14**, 1368-1375 (2008).

**Jerry M Wells**, *Faculty of Animal Sciences, University of Wageningen, The Netherlands*

- Wells, J.M. & Mercenier, A. Mucosal delivery of therapeutic and prophylactic molecules using lactic acid bacteria. *Nat. Rev. Microbiol* **6**, 349-362 (2008).
- Rottiers, P., De Smedt, T. & Steidler, L. Modulation of gut-associated lymphoid tissue functions with genetically modified *Lactococcus lactis*. *Int. Rev. Immunol* **28**, 465-486 (2009).
- Wells, J.M., Rossi, O., Meijerink, M. & van Baarlen, P. Microbes and Health Sackler Colloquium: Epithelial crosstalk at the microbiota-mucosal interface. *Proc Natl Acad Sci U S A*

## Workshop 3 'Therapy and Prevention – Emerging Concepts'

### Session 1: Tolerance Induction - Preclinical/Clinical Studies

**Markus Neurath**, *Department of Medicine, University of Erlangen-Nürnberg, Germany*

- Kaser, A., Zeissig, S. & Blumberg, R.S. Inflammatory bowel disease. *Annu. Rev. Immunol* **28**, 573-621 (2010).
- Neurath, M.F. & Finotto, S. Translating inflammatory bowel disease research into clinical medicine. *Immunity* **31**, 357-361 (2009).
- Xavier, R.J. & Podolsky, D.K. Unravelling the pathogenesis of inflammatory bowel disease. *Nature* **448**, 427-434 (2007).

**Jürgen Schwarze**, *Queens Medical Research Institute, University of Edinburgh, United Kingdom*

- Akdis, M. & Akdis, C.A. Therapeutic manipulation of immune tolerance in allergic disease. *Nat Rev Drug Discov* **8**, 645-660 (2009).
- Cochrane, S. et al. Factors influencing the incidence and prevalence of food allergy. *Allergy* **64**, 1246-1255 (2009).
- Sicherer, S.H. & Sampson, H.A. Food allergy. *J. Allergy Clin. Immunol* **125**, S116-125 (2010).

**Charlotte Braun-Fahrländer**, *Institute of Social and Preventive Medicine, University of Basel, Switzerland*

- Sheikh, A. & Strachan, D.P. The hygiene theory: fact or fiction? *Curr Opin Otolaryngol Head Neck Surg* **12**, 232-236 (2004).
- von Mutius, E. 99th Dahlem conference on infection, inflammation and chronic inflammatory disorders: farm lifestyles and the hygiene hypothesis. *Clin. Exp. Immunol* **160**, 130-135 (2010).
- von Mutius, E. & Radon, K. Living on a farm: impact on asthma induction and clinical course. *Immunol Allergy Clin North Am* **28**, 631-647, ix-x (2008).

### Session 2: Therapeutic Intervention

**Stephen Holgate**, *Southampton General Hospital, United Kingdom*

- Barnes, P.J. New therapies for asthma: is there any progress? *Trends Pharmacol. Sci* **31**, 335-343 (2010).
- Holgate, S.T. A look at the pathogenesis of asthma: the need for a change in direction. *Discov Med* **9**, 439-447 (2010).
- Schachter, E.N. & Neuman, T. The use of monoclonal antibodies and related agents in the treatment of respiratory disease. *Drugs Today* **45**, 533-548 (2009).

**Ursula Wiedermann**, *Institute of Specific Prophylaxis and Tropical Medicine, Medical University of Vienna, Austria*

- Wiedermann, U. Hitting the mucosal road in tolerance induction. *Nestle Nutr Workshop Ser Pediatr Program* **64**, 63-72; discussion 72-74, 251-257 (2009).
- Wiedermann, U. Prophylaxis and therapy of allergy by mucosal tolerance induction with recombinant allergens or allergen constructs. *Curr Drug Targets Inflamm Allergy* **4**, 577-583 (2005).
- Schabussova, I. & Wiedermann, U. Lactic acid bacteria as novel adjuvant systems for prevention and treatment of atopic diseases. *Curr Opin Allergy Clin Immunol* **8**, 557-564 (2008).

### Session 3: Prevention

**Berthold Koletzko**, *Dr. von Hauner Children's Hospital, Ludwig-Maximilians University, Munich, Germany*

- Koletzko, B. Innovations in infant milk feeding: from the past to the future. *Nestle Nutr Workshop Ser Pediatr Program* **66**, 1-17 (2010).
- Koletzko, B. & al. Early nutrition programming and health outcomes in later life: obesity and beyond. *Adv Exp Med Biol New York Springer*, 1-196 (2009).
- Koletzko, B. et al. Lower protein in infant formula is associated with lower weight up to age 2 y: a randomized clinical trial. *Am. J. Clin. Nutr* **89**, 1836-1845 (2009).

**Matthias Kopp**, *Klinik für Kinder- und Jugendmedizin, Universitätsklinikum Schleswig-Holstein, Germany*

- Johannsen, H. & Prescott, S.L. Practical prebiotics, probiotics and synbiotics for allergists: how useful are they? *Clin. Exp. Allergy* **39**, 1801-1814 (2009).
- Pan, S. et al. Probiotics and allergy in children--an update review. *Pediatr Allergy Immunol* **21**, e659-666 (2010).
- Kopp, M.V. & Salfeld, P. Probiotics and prevention of allergic disease. *Curr Opin Clin Nutr Metab Care* **12**, 298-303 (2009).

**Francisco Guarner**, *University Hospital Vall d'Hebron, Barcelona, Spain*

- Guarner, F. What is the role of the enteric commensal flora in IBD? *Inflamm. Bowel Dis* **14 Suppl 2**, S83-84 (2008).
- Guarner, F. et al. Mechanisms of disease: the hygiene hypothesis revisited. *Nat Clin Pract Gastroenterol Hepatol* **3**, 275-284 (2006).
- Qin, J. et al. A human gut microbial gene catalogue established by metagenomic sequencing. *Nature* **464**, 59-65 (2010).



- World Gastroenterology Organization Global Guideline 'Probiotics and Prebiotics in Gastroenterology'. [www.worldgastroenterology.org](http://www.worldgastroenterology.org) (2008).

**Lothar Steidler**, *ActoGeniX NV, Zwijnaarde, Belgium*

- Rottiers, P., De Smedt, T. & Steidler, L. Modulation of gut-associated lymphoid tissue functions with genetically modified *Lactococcus lactis*. *Int. Rev. Immunol* **28**, 465-486 (2009).
- Steidler, L., Rottiers, P. & Coulie, B. Actobiotics as a novel method for cytokine delivery. *Ann. N. Y. Acad. Sci* **1182**, 135-145 (2009).
- Wells, J.M. & Mercenier, A. Mucosal delivery of therapeutic and prophylactic molecules using lactic acid bacteria. *Nat. Rev. Microbiol* **6**, 349-362 (2008).

**Seppo Salminen**, *Functional Foods Forum, University of Turku, Finland*

- Salminen, S. et al. Interaction of probiotics and pathogens--benefits to human health? *Curr. Opin. Biotechnol* **21**, 157-167 (2010).
- Lenoir-Wijnkoop, I. et al. Nutrition economics - characterising the economic and health impact of nutrition. *Br J Nutr* **1-9** (2010).doi:10.1017/S0007114510003041
- Salminen, S. et al. Functional food science and gastrointestinal physiology and function. *Br. J. Nutr* **80 Suppl 1**, S147-171 (1998).

**Sibylle Koletzko**, *Dr. von Hauner Children's Hospital, Ludwig-Maximilians University, Munich, Germany*

- Szajewska, H. & Horvath, A. Meta-analysis of the evidence for a partially hydrolyzed 100% whey formula for the prevention of allergic diseases. *Curr Med Res Opin* **26**, 423-437 (2010).
- Verhasselt, V. Oral tolerance in neonates: from basics to potential prevention of allergic disease. *Mucosal Immunol* **3**, 326-333 (2010).
- Osborn, D. & Sinn, J. Formulas containing hydrolysed protein for prevention of allergy and food intolerance in infants (Review). *The Cochrane Library* 1-138 (2009).

**John Hollingsworth**, *Duke University Medical Centre, Durham, United States*

- Hollingsworth, J.W. et al. In utero supplementation with methyl donors enhances allergic airway disease in mice. *J. Clin. Invest* **118**, 3462-3469 (2008).
- Jirtle, R.L. & Skinner, M.K. Environmental epigenomics and disease susceptibility. *Nat. Rev. Genet* **8**, 253-262 (2007).
- Håberg, S.E., London, S.J., Stigum, H., Nafstad, P. & Nystad, W. Folic acid supplements in pregnancy and early childhood respiratory health. *Arch. Dis. Child* **94**, 180-184 (2009).
- Whitrow, M.J., Moore, V.M., Rumbold, A.R. & Davies, M.J. Effect of supplemental folic acid in pregnancy on childhood asthma: a prospective birth cohort study. *Am. J. Epidemiol* **170**, 1486-1493 (2009).

**Graham Devereux**, *Applied Health Sciences, University of Aberdeen, United Kingdom*

- Allan, K., Kelly, F.J. & Devereux, G. Antioxidants and allergic disease: a case of too little or too much? *Clin. Exp. Allergy* **40**, 370-380 (2010).
- van Schayck, O.C.P., Maas, T., Kaper, J., Knottnerus, A.J.A. & Sheikh, A. Is there any role for allergen avoidance in the primary prevention of childhood asthma? *J. Allergy Clin. Immunol* **119**, 1323-1328 (2007).
- Devereux, G. & Wagner, J.G. Vitamin D and asthma: scientific promise and clinical reality. *in press*

## Extras Reviews

**Steven Shoelson**, *Joslin Diabetes Center, Boston, United States, apologies*

- Hotamisligil, G.S. & Erbay, E. Nutrient sensing and inflammation in metabolic diseases. *Nat. Rev. Immunol* **8**, 923-934 (2008).
- Shoelson, S.E., Lee, J. & Goldfine, A.B. Inflammation and insulin resistance. *J. Clin. Invest* **116**, 1793-1801 (2006).
- Shoelson, S.E. & Goldfine, A.B. Fanning the flames of obesity-induced inflammation. *Nature Medicine* **15**, 373-374 (2009).

**William Agace**, *Lund University, Sweden, apologies*

- Moro, J.R., Iwata, M. & von Andriano, U.H. Vitamin effects on the immune system: vitamins A and D take centre stage. *Nat. Rev. Immunol* **8**, 685-698 (2008).
- Coombes, J.L. & Powrie, F. Dendritic cells in intestinal immune regulation. *Nat. Rev. Immunol* **8**, 435-446 (2008).
- Agace, W.W. T-cell recruitment to the intestinal mucosa. *Trends Immunol* **29**, 514-522 (2008).

**Philippe Sansonetti**, *Institut Pasteur, INSERM, Paris, France, apologies*

- Cossart, P. & Sansonetti, P.J. Bacterial invasion: the paradigms of enteroinvasive pathogens. *Science* **304**, 242-248 (2004).
- Phalipon, A. & Sansonetti, P.J. Shigella's ways of manipulating the host intestinal innate and adaptive immune system: a tool box for survival? *Immunol. Cell Biol* **85**, 119-129 (2007).
- Sansonetti, P.J. War and peace at mucosal surfaces. *Nat. Rev. Immunol* **4**, 953-964 (2004).
- Sansonetti, P.J. & Medzhitov, R. Learning tolerance while fighting ignorance. *Cell* **138**, 416-420 (2009).



## Selection of reviews by first author

1. Abraham, S.N. & St John, A.L. Mast cell-orchestrated immunity to pathogens. *Nat. Rev. Immunol* **10**, 440-452 (2010).
2. Abt, M.C. & Artis, D. The intestinal microbiota in health and disease: the influence of microbial products on immune cell homeostasis. *Curr. Opin. Gastroenterol* **25**, 496-502 (2009).
3. Adlerberth, I. & Wold, A.E. Establishment of the gut microbiota in Western infants. *Acta Paediatr* **98**, 229-238 (2009).
4. Agace, W.W. T-cell recruitment to the intestinal mucosa. *Trends Immunol* **29**, 514-522 (2008).
5. Agace, W. Generation of gut-homing T cells and their localization to the small intestinal mucosa. *Immunol. Lett* **128**, 21-23 (2010).
6. Akdis, M. & Akdis, C.A. Therapeutic manipulation of immune tolerance in allergic disease. *Nat Rev Drug Discov* **8**, 645-660 (2009).
7. Allan, K., Kelly, F.J. & Devereux, G. Antioxidants and allergic disease: a case of too little or too much? *Clin. Exp. Allergy* **40**, 370-380 (2010).
8. Bäckhed, F., Ley, R.E., Sonnenburg, J.L., Peterson, D.A. & Gordon, J.I. Host-bacterial mutualism in the human intestine. *Science* **307**, 1915-1920 (2005).
9. Barnes, P.J. New therapies for asthma: is there any progress? *Trends Pharmacol. Sci* **31**, 335-343 (2010).
10. Barnes, M.J. & Powrie, F. Regulatory T cells reinforce intestinal homeostasis. *Immunity* **31**, 401-411 (2009).
11. Bischoff, S.C. Role of mast cells in allergic and non-allergic immune responses: comparison of human and murine data. *Nat. Rev. Immunol* **7**, 93-104 (2007).
12. Booiijink, C.C.G.M., Zoetendal, E.G., Kleerebezem, M. & de Vos, W.M. Microbial communities in the human small intestine: coupling diversity to metagenomics. *Future Microbiol* **2**, 285-295 (2007).
13. Brandtzaeg, P. Update on mucosal immunoglobulin A in gastrointestinal disease. *Curr Opin Gastroenterol* (2010).doi:10.1097/MOG.0b013e32833dccc8
14. Brennan, P. et al. Obesity and cancer: Mendelian randomization approach utilizing the FTO genotype. *Int J Epidemiol* **38**, 971-975 (2009).
15. Carroll, I.M., Threadgill, D.W. & Threadgill, D.S. The gastrointestinal microbiome: a malleable, third genome of mammals. *Mamm. Genome* **20**, 395-403 (2009).
16. Cebra, J.J. Influences of microbiota on intestinal immune system development. *Am. J. Clin. Nutr* **69**, 1046S-1051S (1999).
17. Cerf-Bensussan, N. & Gaboriau-Routhiau, V. The immune system and the gut microbiota: friends or foes? *Nat. Rev. Immunol* **10**, 735-744 (2010).
18. Chervonsky, A.V. Influence of microbial environment on autoimmunity. *Nat. Immunol* **11**, 28-35 (2010).
19. Cho, J.H. The genetics and immunopathogenesis of inflammatory bowel disease. *Nat. Rev. Immunol* **8**, 458-466 (2008).
20. Cochrane, S. et al. Factors influencing the incidence and prevalence of food allergy. *Allergy* **64**, 1246-1255 (2009).
21. Collins, S.M. & Bercik, P. The relationship between intestinal microbiota and the central nervous system in normal gastrointestinal function and disease. *Gastroenterology* **136**, 2003-2014 (2009).
22. Coombes, J.L. & Powrie, F. Dendritic cells in intestinal immune regulation. *Nat. Rev. Immunol* **8**, 435-446 (2008).
23. Cooper, M.A., Colonna, M. & Yokoyama, W.M. Hidden talents of natural killers: NK cells in innate and adaptive immunity. *EMBO Rep* **10**, 1103-1110 (2009).
24. Cosio, M.G., Saetta, M. & Agusti, A. Immunologic aspects of chronic obstructive pulmonary disease. *N. Engl. J. Med* **360**, 2445-2454 (2009).
25. Cossart, P. & Sansonetti, P.J. Bacterial invasion: the paradigms of enteroinvasive pathogens. *Science* **304**, 242-248 (2004).
26. Devereux, G. & Wagner, J.G. Vitamin D and asthma: scientific promise and clinical reality. *in press*
27. Diefenbach, A. & Vonarbourg, C. Innate lymphocytes induce inflammatory bowel disease. *Immunol Cell Biol* (2010).doi:10.1038/icb.2010.82
28. Douwes, J., Brooks, C. & Pearce, N. Protective effects of farming on allergies and asthma: have we learnt anything since 1873? *Expert Rev Clin Immunol* **5**, 213-219 (2009).
29. Ehrlich, S.D. & MetaHIT consortium Metagenomics of the intestinal microbiota: potential applications. *Gastroenterologie Clinique et Biologique* (2010).
30. Fillatreau, S., Gray, D. & Anderton, S.M. Not always the bad guys: B cells as regulators of autoimmune pathology. *Nat. Rev. Immunol* **8**, 391-397 (2008).
31. Flint, H.J., Duncan, S.H., Scott, K.P. & Louis, P. Interactions and competition within the microbial community of the human colon: links between diet and health. *Environ. Microbiol* **9**, 1101-1111 (2007).
32. Ford, E.S. et al. Healthy living is the best revenge: findings from the European Prospective Investigation Into Cancer and Nutrition-Potsdam study. *Arch. Intern. Med* **169**, 1355-1362 (2009).
33. Forsythe, P., Sudo, N., Dinan, T., Taylor, V.H. & Bienenstock, J. Mood and gut feelings. *Brain Behav. Immun* **24**, 9-16 (2010).
34. Freestone, P.P.E., Sandrini, S.M., Haigh, R.D. & Lyte, M. Microbial endocrinology: how stress influences susceptibility to infection. *Trends Microbiol* **16**, 55-64 (2008).
35. Garantziotis, S. & Schwartz, D.A. Ecogenomics of respiratory diseases of public health significance. *Annu Rev Public Health* **31**, 37-51 1 p following 51 (2010).
36. Garrett, W.S., Gordon, J.I. & Glimcher, L.H. Homeostasis and inflammation in the intestine. *Cell* **140**, 859-870 (2010).
37. Ghosh, S. & Hayden, M.S. New regulators of NF-kappaB in inflammation. *Nat. Rev. Immunol* **8**, 837-848 (2008).
38. Grivennikov, S.I., Greten, F.R. & Karin, M. Immunity, inflammation, and cancer. *Cell* **140**, 883-899 (2010).
39. Guarner, F. What is the role of the enteric

- commensal flora in IBD? *Inflamm. Bowel Dis* **14 Suppl 2**, S83-84 (2008).
40. Guarner, F. et al. Mechanisms of disease: the hygiene hypothesis revisited. *Nat Clin Pract Gastroenterol Hepatol* **3**, 275-284 (2006).
41. Håberg, S.E., London, S.J., Stigum, H., Nafstad, P. & Nystad, W. Folic acid supplements in pregnancy and early childhood respiratory health. *Arch. Dis. Child* **94**, 180-184 (2009).
42. Hamady, M. & Knight, R. Microbial community profiling for human microbiome projects: Tools, techniques, and challenges. *Genome Res* **19**, 1141-1152 (2009).
43. Hammad, H. & Lambrecht, B.N. Dendritic cells and epithelial cells: linking innate and adaptive immunity in asthma. *Nat. Rev. Immunol* **8**, 193-204 (2008).
44. Heijmans, B.T., Tobi, E.W., Lumey, L.H. & Slagboom, P.E. The epigenome: archive of the prenatal environment. *Epigenetics* **4**, 526-531 (2009).
45. Holgate, S.T. A look at the pathogenesis of asthma: the need for a change in direction. *Discov Med* **9**, 439-447 (2010).
46. Hollingsworth, J.W. et al. In utero supplementation with methyl donors enhances allergic airway disease in mice. *J. Clin. Invest* **118**, 3462-3469 (2008).
47. Hooper, L.V. & Macpherson, A.J. Immune adaptations that maintain homeostasis with the intestinal microbiota. *Nat. Rev. Immunol* **10**, 159-169 (2010).
48. Hotamisligil, G.S. & Erbay, E. Nutrient sensing and inflammation in metabolic diseases. *Nat. Rev. Immunol* **8**, 923-934 (2008).
49. Huehn, J., Polansky, J.K. & Hamann, A. Epigenetic control of FOXP3 expression: the key to a stable regulatory T-cell lineage? *Nat. Rev. Immunol* **9**, 83-89 (2009).
50. Hunter, D.J. Gene-environment interactions in human diseases. *Nat. Rev. Genet* **6**, 287-298 (2005).
51. Illner, A., Nöthlings, U., Wagner, K., Ward, H. & Boeing, H. The assessment of individual usual food intake in large-scale prospective studies. *Ann. Nutr. Metab* **56**, 99-105 (2010).
52. Isolauri, E., Sütas, Y., Kankaanpää, P., Arvilommi, H. & Salminen, S. Probiotics: effects on immunity. *Am. J. Clin. Nutr* **73**, 444S-450S (2001).
53. Isolauri, E., Rautava, S., Kalliomäki, M., Kirjavainen, P. & Salminen, S. Role of probiotics in food hypersensitivity. *Curr Opin Allergy Clin Immunol* **2**, 263-271 (2002).
54. Isolauri, E., Kalliomäki, M., Laitinen, K. & Salminen, S. Modulation of the maturing gut barrier and microbiota: a novel target in allergic disease. *Curr. Pharm. Des* **14**, 1368-1375 (2008).
55. Iwata, M. Retinoic acid production by intestinal dendritic cells and its role in T-cell trafficking. *Semin. Immunol* **21**, 8-13 (2009).
56. Janson, P.C.J., Winerdal, M.E. & Winqvist, O. At the crossroads of T helper lineage commitment- Epigenetics points the way. *Biochim. Biophys. Acta* **1790**, 906-919 (2009).
57. Jirtle, R.L. & Skinner, M.K. Environmental epigenomics and disease susceptibility. *Nat. Rev. Genet* **8**, 253-262 (2007).
58. Johannsen, H. & Prescott, S.L. Practical prebiotics, probiotics and synbiotics for allergists: how useful are they? *Clin. Exp. Allergy* **39**, 1801-1814 (2009).
59. Joost, H. Pathogenesis, risk assessment and prevention of type 2 diabetes mellitus. *Obes Facts* **1**, 128-137 (2008).
60. Kalesnikoff, J. & Galli, S.J. New developments in mast cell biology. *Nat. Immunol* **9**, 1215-1223 (2008).
61. Kaser, A., Zeissig, S. & Blumberg, R.S. Inflammatory bowel disease. *Annu. Rev. Immunol* **28**, 573-621 (2010).
62. Kaser, A., Martínez-Naves, E. & Blumberg, R.S. Endoplasmic reticulum stress: implications for inflammatory bowel disease pathogenesis. *Curr. Opin. Gastroenterol* **26**, 318-326 (2010).
63. Kaser, A. & Blumberg, R.S. Endoplasmic reticulum stress and intestinal inflammation. *Mucosal Immunol* **3**, 11-16 (2010).
64. Kauffmann, F., Castro-Giner, F., Smit, L.A.M., Nadif, R. & Kogenivas, M. Gene-environment interactions in occupational asthma. *Occupational Asthma* 205-228 (2010).
65. Kawai, T. & Akira, S. The role of pattern-recognition receptors in innate immunity: update on Toll-like receptors. *Nat. Immunol* **11**, 373-384 (2010).
66. Kelly, D., Conway, S. & Aminov, R. Commensal gut bacteria: mechanisms of immune modulation. *Trends Immunol* **26**, 326-333 (2005).
67. Kelsall, B. Recent progress in understanding the phenotype and function of intestinal dendritic cells and macrophages. *Mucosal Immunol* **1**, 460-469 (2008).
68. Kersten, S. Regulation of nutrient metabolism and inflammation. *Results Probl Cell Differ* **52**, 13-25 (2010).
69. Kim, H.Y., DeKruyff, R.H. & Umetsu, D.T. The many paths to asthma: phenotype shaped by innate and adaptive immunity. *Nat. Immunol* **11**, 577-584 (2010).
70. Kleerebezem, M. & Vaughan, E.E. Probiotic and gut lactobacilli and bifidobacteria: molecular approaches to study diversity and activity. *Annu. Rev. Microbiol* **63**, 269-290 (2009).
71. Koletzko, B. Innovations in infant milk feeding: from the past to the future. *Nestle Nutr Workshop Ser Pediatr Program* **66**, 1-17 (2010).
72. Koletzko, B. & al. Early nutrition programming and health outcomes in later life: obesity and beyond. *Adv Exp Med Biol New York Springer*, 1-196 (2009).
73. Koletzko, B. et al. Lower protein in infant formula is associated with lower weight up to age 2 y: a randomized clinical trial. *Am. J. Clin. Nutr* **89**, 1836-1845 (2009).
74. Kopp, M.V. & Salfeld, P. Probiotics and prevention of allergic disease. *Curr Opin Clin Nutr Metab Care* **12**, 298-303 (2009).
75. Korthals, M., Ege, M.J., Tebbe, C.C., von Mutius, E. & Bauer, J. Application of PCR-SSCP for molecular epidemiological studies on the exposure of farm children to bacteria in environmental dust. *J. Microbiol. Methods* **73**, 49-56 (2008).
76. Kretschmer, K., Apostolou, I., Verginis, P. & von Boehmer, H. Regulatory T cells and antigen-specific tolerance. *Chem Immunol Allergy* **94**, 8-15 (2008).
77. Kuczynski, J. et al. Direct sequencing of the human

- microbiome readily reveals community differences. *Genome Biol* **11**, 210 (2010).
78. Lenoir-Wijnkoop, I. et al. Nutrition economics - characterising the economic and health impact of nutrition. *Br J Nutr* 1-9 (2010).doi:10.1017/S0007114510003041
  79. Ley, R.E., Lozupone, C.A., Hamady, M., Knight, R. & Gordon, J.I. Worlds within worlds: evolution of the vertebrate gut microbiota. *Nat. Rev. Microbiol* **6**, 776-788 (2008).
  80. Lund, F.E. & Randall, T.D. Effector and regulatory B cells: modulators of CD4(+) T cell immunity. *Nat. Rev. Immunol* **10**, 236-247 (2010).
  81. Marchiando, A.M., Graham, W.V. & Turner, J.R. Epithelial barriers in homeostasis and disease. *Annu Rev Pathol* **5**, 119-144 (2010).
  82. Meyers, D.A. Genetics of asthma and allergy: what have we learned? *J. Allergy Clin. Immunol* **126**, 439-446; quiz 447-448 (2010).
  83. Moro, J.R., Iwata, M. & von Andriano, U.H. Vitamin effects on the immune system: vitamins A and D take centre stage. *Nat. Rev. Immunol* **8**, 685-698 (2008).
  84. Müller, M. & Kersten, S. Nutrigenomics: goals and strategies. *Nat. Rev. Genet* **4**, 315-322 (2003).
  85. Nathan, C. & Ding, A. Nonresolving inflammation. *Cell* **140**, 871-882 (2010).
  86. Neurath, M.F. & Finotto, S. Translating inflammatory bowel disease research into clinical medicine. *Immunity* **31**, 357-361 (2009).
  87. Okada, H., Kuhn, C., Feillet, H. & Bach, J. The 'hygiene hypothesis' for autoimmune and allergic diseases: an update. *Clin. Exp. Immunol* **160**, 1-9 (2010).
  88. O'Neill, L.A.J. When signaling pathways collide: positive and negative regulation of toll-like receptor signal transduction. *Immunity* **29**, 12-20 (2008).
  89. O'Rahilly, S. Human genetics illuminates the paths to metabolic disease. *Nature* **462**, 307-314 (2009).
  90. Osborn, D. & Sinn, J. Formulas containing hydrolysed protein for prevention of allergy and food intolerance in infants (Review). *The Cochrane Library* 1-138 (2009).
  91. Pan, S. et al. Probiotics and allergy in children--an update review. *Pediatr Allergy Immunol* **21**, e659-666 (2010).
  92. Pasparakis, M. Regulation of tissue homeostasis by NF-kappaB signalling: implications for inflammatory diseases. *Nat. Rev. Immunol* **9**, 778-788 (2009).
  93. Phalipon, A. & Sansonetti, P.J. Shigella's ways of manipulating the host intestinal innate and adaptive immune system: a tool box for survival? *Immunol. Cell Biol* **85**, 119-129 (2007).
  94. Pineton de Chambrun, G., Colombel, J., Poulain, D. & Darfeuille-Michaud, A. Pathogenic agents in inflammatory bowel diseases. *Curr. Opin. Gastroenterol* **24**, 440-447 (2008).
  95. Platt, A.M. & Mowat, A.M. Mucosal macrophages and the regulation of immune responses in the intestine. *Immunol. Lett* **119**, 22-31 (2008).
  96. Qin, J. et al. A human gut microbial gene catalogue established by metagenomic sequencing. *Nature* **464**, 59-65 (2010).
  97. Reiff, C. et al. Balancing inflammatory, lipid, and xenobiotic signaling pathways by VSL#3, a biotherapeutic agent, in the treatment of inflammatory bowel disease. *Inflamm. Bowel Dis* **15**, 1721-1736 (2009).
  98. Reiff, C. & Kelly, D. Inflammatory bowel disease, gut bacteria and probiotic therapy. *Int. J. Med. Microbiol* **300**, 25-33 (2010).
  99. Rescigno, M. & Di Sabatino, A. Dendritic cells in intestinal homeostasis and disease. *J. Clin. Invest* **119**, 2441-2450 (2009).
  100. Rottiers, P., De Smedt, T. & Steidler, L. Modulation of gut-associated lymphoid tissue functions with genetically modified *Lactococcus lactis*. *Int. Rev. Immunol* **28**, 465-486 (2009).
  101. Round, J.L. & Mazmanian, S.K. The gut microbiota shapes intestinal immune responses during health and disease. *Nat. Rev. Immunol* **9**, 313-323 (2009).
  102. Salminen, S. et al. Functional food science and gastrointestinal physiology and function. *Br. J. Nutr* **80 Suppl 1**, S147-171 (1998).
  103. Salminen, S. et al. Interaction of probiotics and pathogens--benefits to human health? *Curr. Opin. Biotechnol* **21**, 157-167 (2010).
  104. Sansonetti, P.J. War and peace at mucosal surfaces. *Nat. Rev. Immunol* **4**, 953-964 (2004).
  105. Sansonetti, P.J. & Medzhitov, R. Learning tolerance while fighting ignorance. *Cell* **138**, 416-420 (2009).
  106. Schabussova, I. & Wiedermann, U. Lactic acid bacteria as novel adjuvant systems for prevention and treatment of atopic diseases. *Curr Opin Allergy Clin Immunol* **8**, 557-564 (2008).
  107. Schachter, E.N. & Neuman, T. The use of monoclonal antibodies and related agents in the treatment of respiratory disease. *Drugs Today* **45**, 533-548 (2009).
  108. Sheikh, A. & Strachan, D.P. The hygiene theory: fact or fiction? *Curr Opin Otolaryngol Head Neck Surg* **12**, 232-236 (2004).
  109. Shoelson, S.E., Lee, J. & Goldfine, A.B. Inflammation and insulin resistance. *J. Clin. Invest* **116**, 1793-1801 (2006).
  110. Shoelson, S.E. & Goldfine, A.B. Fanning the flames of obesity-induced inflammation. *Nature Medicine* **15**, 373-374 (2009).
  111. Sicherer, S.H. & Sampson, H.A. Food allergy. *J. Allergy Clin. Immunol* **125**, S116-125 (2010).
  112. Simpson, A. & Martinez, F.D. The role of lipopolysaccharide in the development of atopy in humans. *Clin. Exp. Allergy* **40**, 209-223 (2010).
  113. Steidler, L., Rottiers, P. & Coulie, B. Actobiotics as a novel method for cytokine delivery. *Ann. N. Y. Acad. Sci* **1182**, 135-145 (2009).
  114. Stöger, R. The thrifty epigenotype: an acquired and heritable predisposition for obesity and diabetes? *Bioessays* **30**, 156-166 (2008).
  115. Swindle, E.J., Collins, J.E. & Davies, D.E. Breakdown in epithelial barrier function in patients with asthma: identification of novel therapeutic approaches. *J. Allergy Clin. Immunol* **124**, 23-34; quiz 35-36 (2009).
  116. Szajewska, H. & Horvath, A. Meta-analysis of the evidence for a partially hydrolyzed 100% whey formula for the prevention of allergic diseases. *Curr Med Res Opin* **26**, 423-437 (2010).
  117. Szendroedi, J. & Roden, M. Mitochondrial fitness and insulin sensitivity in humans. *Diabetologia* **51**, 2155-

- 2167 (2008).
118. Tlaskalová-Hogenová, H. et al. Commensal bacteria (normal microflora), mucosal immunity and chronic inflammatory and autoimmune diseases. *Immunol. Lett* **93**, 97-108 (2004).
  119. Todd, J.A. Etiology of type 1 diabetes. *Immunity* **32**, 457-467 (2010).
  120. van Schayck, O.C.P., Maas, T., Kaper, J., Knottnerus, A.J.A. & Sheikh, A. Is there any role for allergen avoidance in the primary prevention of childhood asthma? *J. Allergy Clin. Immunol* **119**, 1323-1328 (2007).
  121. Vercelli, D. Gene-environment interactions in asthma and allergy: the end of the beginning? *Curr Opin Allergy Clin Immunol* **10**, 145-148 (2010).
  122. Verhasselt, V. Oral tolerance in neonates: from basics to potential prevention of allergic disease. *Mucosal Immunol* **3**, 326-333 (2010).
  123. Vivier, E., Spits, H. & Cupedo, T. Interleukin-22-producing innate immune cells: new players in mucosal immunity and tissue repair? *Nat. Rev. Immunol* **9**, 229-234 (2009).
  124. von Boehmer, H. Oral tolerance: is it all retinoic acid? *J. Exp. Med* **204**, 1737-1739 (2007).
  125. von Mutius, E. 99th Dahlem conference on infection, inflammation and chronic inflammatory disorders: farm lifestyles and the hygiene hypothesis. *Clin. Exp. Immunol* **160**, 130-135 (2010).
  126. von Mutius, E. & Radon, K. Living on a farm: impact on asthma induction and clinical course. *Immunol Allergy Clin North Am* **28**, 631-647, ix-x (2008).
  127. Vrieze, A. et al. The environment within: how gut microbiota may influence metabolism and body composition. *Diabetologia* **53**, 606-613 (2010).
  128. Waterland, R.A. & Michels, K.B. Epigenetic epidemiology of the developmental origins hypothesis. *Annu. Rev. Nutr* **27**, 363-388 (2007).
  129. Wekerle, H. & Kurschus, F.C. Animals models of multiple sclerosis. *Drug Discovery Today: Disease Models* **3**, 359-367 (2005).
  130. Wells, J.M., Rossi, O., Meijerink, M. & van Baarlen, P. Microbes and Health Sackler Colloquium: Epithelial crosstalk at the microbiota-mucosal interface. *Proc Natl Acad Sci U S A* (2010).doi:10.1073/pnas.1000092107
  131. Wells, J.M. & Mercenier, A. Mucosal delivery of therapeutic and prophylactic molecules using lactic acid bacteria. *Nat. Rev. Microbiol* **6**, 349-362 (2008).
  132. Whitrow, M.J., Moore, V.M., Rumbold, A.R. & Davies, M.J. Effect of supplemental folic acid in pregnancy on childhood asthma: a prospective birth cohort study. *Am. J. Epidemiol* **170**, 1486-1493 (2009).
  133. Wiedermann, U. Prophylaxis and therapy of allergy by mucosal tolerance induction with recombinant allergens or allergen constructs. *Curr Drug Targets Inflamm Allergy* **4**, 577-583 (2005).
  134. Wiedermann, U. Hitting the mucosal road in tolerance induction. *Nestle Nutr Workshop Ser Pediatr Program* **64**, 63-72; discussion 72-74, 251-257 (2009).
  135. Wilson, C.B., Rowell, E. & Sekimata, M. Epigenetic control of T-helper-cell differentiation. *Nat. Rev. Immunol* **9**, 91-105 (2009).
  136. World Gastroenterology Organization Global Guideline 'Probiotics and Prebiotics in Gastroenterology'. [www.worldgastroenterology.org](http://www.worldgastroenterology.org) (2008).
  137. Xavier, R.J. & Podolsky, D.K. Unravelling the pathogenesis of inflammatory bowel disease. *Nature* **448**, 427-434 (2007).
  138. Ziegler, A. & Nepom, G.T. Prediction and pathogenesis in type 1 diabetes. *Immunity* **32**, 468-478 (2010).
  139. Zoetendal, E.G., Rajilic-Stojanovic, M. & de Vos, W.M. High-throughput diversity and functionality analysis of the gastrointestinal tract microbiota. *Gut* **57**, 1605-1615 (2008).

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