

Workshop on European Glycoscience White Paper

Carlsberg Research Laboratory Copenhagen

9-10th March 2014

1. Scientific report

Summary

The participants came from 10 countries and represented both Academic and Commercial research. The purpose of this workshop was to finalise a ESF policy briefing paper on the Future of European Glycoscience. A number of European Glycoscientists who are recognised leaders in diverse fields of glycoscience were invited to discuss and finalise a draft which will be circulated previous to the meeting. The paper aims to outline a roadmap for future activities in Europe and interactions with similar activities on an international level. During the meeting it was proposed that instead of a single White Paper encompassing all areas there should instead be a series of targeted White Papers meeting specific audiences. ESF should also be approached to publish a brochure outlining the achievements of the Euroglycoforum Research Network Programme and the areas of expertise and prospects for application of the considerable body of European research work in this area

Description of the scientific content of and discussions at the event

Introduction

Several important points of view came out of the meeting and the most important were considered to be the Integration of glycoscience with other biosciences – glycans should not be considered as different entities, the importance of glycosylation changes in disease processes, that Glycans are integral to cell biology – influence of glycosylation on physiological properties of any biomolecules (proteins, lipids, metabolites), point out that Glycosylation is dynamic and plays key role in innate and adaptive immunity, the very high presence on human cell surfaces and on microbial cell surfaces, recognition that arbohydrates provide biggest biomass on earth - resource for materials and energy and that Glycans have diverse functions in different biological contexts.

There has been considerable progress in the following areas in the last few years with European scientists playing a major role;

1. Synthesis including chemical, automated, enzymatic, microbial synthesis¹
2. High-throughput automated analysis – instrumentation commercially available²
3. Informatics and modelling³
4. European publications in Glycoscience⁴
5. ERC grants/EC grants/ number of EU consortia funded⁵
6. Glycoengineering of cell lines⁶
7. Highly successful training courses
8. Pfizer (PREVNAL) largest selling product⁷
9. 8 out of 10 bestselling biological pharmaceuticals re glycoproteins⁸
10. Carbohydrate Vaccines⁹
11. Serum glycomarkers¹⁰

Future Trends ;

- Larger trans-European coordinated research programmes, with open innovation partnerships between academia and industries;
- Development of cost-effective processes with low carbon footprint;
- Reduced healthcare costs using more effective , more targeted and multi-targeted medicines;
- Food will contribute to the prevention of disease, overall wellbeing especially in old age.
- Enhance European competitiveness through industrial excellence,
- Integrate programmes ensure scientific excellence quickly translated into European Market; support research as well as manufacturing;
- Job creation, fostering entrepreneurship.

European Strengths

- Biopharmaceuticals (synthesis, production, bioprocessing, large market, automated analysis)
- Diagnostics (viral) infections/host-pathogen interactions – follow up; drug-host pathogen interactions glycomarkers esp in combination with existing markers (

¹ Carbohydrate synthesis and biosynthesis technologies for cracking of the glycan code: recent advances. Mrázek H, Weignerová L, Bojarová P, Novák P, Vaněk O, Bezouška K. *Biotechnol Adv.* 2013 Jan-Feb;31(1):17-37.

² A systematic approach to protein glycosylation analysis: a path through the maze. Mariño K, Bones J, Kattla JJ, Rudd PM. *Nat Chem Biol.* 2010 Oct;6(10):713-23.

³ Carbohydrate-protein interactions: a 3D view by NMR. Roldós V, Cañada FJ, Jiménez-Barbero J. *Chembiochem.* 2011 May 2;12(7):990-1005

⁴ Glyconanotechnology. Reichardt NC, Martín-Lomas M, Penadés S. *Chem Soc Rev.* 2013 May 21;42(10):4358-76

⁵ http://cordis.europa.eu/newsearch/index.cfm?page=resultListGET&formid=form_all&oneword=glycoscience&useraction=advanced_search&asft=only&controlsession=false

⁶ N-glycosylation of plant-produced recombinant proteins.

Bosch D, Castilho A, Loos A, Schots A, Steinkellner H.

Curr Pharm Des. 2013;19(31):5503-12.

⁷ http://en.wikipedia.org/wiki/Pneumococcal_conjugate_vaccine

⁸ <http://www.fiercepharma.com/special-reports/15-best-selling-drugs-2012>

⁹ <http://onlinelibrary.wiley.com/doi/10.1002/9780470473283.fmatter/pdf>

¹⁰ <http://www.biochemistry.org/Conferences/AllConferences/tabid/379/Filter/64/Page/1/MeetingNo/IND55/view/Conference/Default.aspx>

- Personalised medicine;databases; responders to drugs); drug delivery; diagnostic imaging; antibody-drug complexes; organ transplantation;
- regenerative medicine (stem cells);
- particles across blood brain barrier; small molecule probes/therapeutics;
- anti-carbohydrate antibodies;
- diabetes/obesity; autoimmune diseases; inflammatory diseases;
- nanomedicine; biosensors ;
- polysaccharides as medical devices beta1,3,glucan for wound healing;
- pharmacokinetics (half life of proteins depends on glycosylation)

- Food security ; Crop protection, crop production, food coatings; elicitors; growth factors; inducing systemic resistance

- Materials: nanomaterials (nanoparticles; polysaccharides; high margin products from cellulose; bioplastics; polymers/superabsorbers from cellulose;; diagnostics, drug delivery; drug delivery; biocompatible materials; transplants, wound healing; artificial skin; hybrids polys/synthetic materials; implants; biofilms; cosmetics (hyaluronic acids); food coatings; detergents; components of paints/coatings

- Renewable materials (low CO₂ footprint); moving diversity of polysaccharides from chemical plant into crop plant; reuse waste streams; bioremediation (plants for cleaning contaminated land)

- Biomass/sugar beets – bioethanol from cellulose, improved enzymes , new enzymes using oxidative cleavage, yeasts

- Nutrition: probiotics;prebiotics; human milk oligosaccharides; dietary fibre; disease prevention; functional foods; noncaloric sweeteners; replacement of lipids with polysaccharides; gelling agents

- Education; Science areas: synthetic biology ; knock-out of glyco-genes to understand glycosylation; epigenetics; control of cellular processes through glcNAcylation; neuroscience; cross-connected databases; standards databases (examples of industr applications, Waters, Bruker); sugarbind 4x clicks; (KEGG, CAZY..), in silico biology;

- Structure prediction of glycan structure; virtual glycan array screening; Theoretical modelling of protein glycosylation; starch degradation;

- Glycoenzymes (esp from microorganisms) as products, biocatalysts; aminosugars in plants-roles in regulation;

- Synthetic model polysaccharides – eg specific cellulose fragments

There are major challenges which European Glycoscience can address as follows

1. Biopharmaceuticals

Challenges: manipulation of glycosylation of recombinant glycoproteins (eg from CHO cells) for safety and efficacy; manipulation of glycome of Stem cells (for engrafting, making them immunocompetent); real-time glycosylation analysis and quality control; assays for glycan-mediated function; targeting; protection by glycosylation (increasing half-life)

Stakeholders: *Pharma industries; Healthcare sector; instrument manufacturers; biotech companies; biosimilar companies*

2. Polysaccharides for sustainable materials and energy

Cellulose, Hemicellulose, Starch, Chitin, Xyloglucan and other polysaccharides as starting materials

Challenges: structural dynamics (free electron laser, Hamburg); understanding and control of biosynthesis; generation of new high-value/low volume and low-value/high volume materials (including composite) using chemical and enzymatic methods; finding more efficient enzymes for processing; better efficiency in biofuel production; design of biomimetic and smart materials from polysaccharides; novel barrier coatings; natural emulsifiers/amphiphiles; superabsorbers; taylor biodegradability; fillers (chitosan) in wound healing; bioplastics; replacements for bisphenol A; drug delivery; polysaccharides as medical devices;

Stakeholders: *Chemical Industries; Energy Companies; Medical Device companies; Membrane companies; Health Care sector; Biotech; Food ingredients; packaging; biodegradable materials (eg for nappies); Cosmetic companies;*

3. Food – prebiotics, probiotics; health promotion through food

Challenge: understanding the immunity of the gut; understanding the interaction of the (developing) gut/pathogens/commensals and food; functional assays/in vivo biology; influence of gut microbiome on Allergies, infection, autoimmune disease; chronic diseases; dialogue with regulatory bodies; marketing; information of the public; developing novel functional food ingredients, artificial sweeteners; food for veterinary health;

Stakeholders: *Food industries, drinks industries, animal feed industries; human health; Health care;*

4. Personalised Medicine

Patient stratification for personalised medicine; Glycan diagnostics,

Challenges: cheap diagnostic tools, paper (Whitesides); targeted tools; radioglycochemistry; smart nanomaterials; theranostics; small molecules probes/therapeutics; on-body/in-body sensors; pharmacoglycomics; disease monitoring; personalised regenerative medicine; nanomedicine; multiplexing of diagnostics; personalised monitoring of human glycomes (beyond blood group); ethics; education of general public; safety issues; companion diagnostic

Stakeholders: *Diagnostic companies; Pharmaceutical companies; Healthcare systems; Biotech;*

Follow up and Results

The full details of the meeting will be published by the Euroglycoforum in a series of targeted White papers as follows ;

1. To specific scientific or medical disciplines
2. To policy makers and grand awarding bodies
3. To the general public

The ESF will also be approached to produce a Brochure from the Research Networking Programme which will highlight the successes of the **EUROGLYCOFORUM** and to present areas for future commercial exploitation.

Annexe 1

Programme of the meeting and full list of speakers and participants.



Workshop on European Glycoscience Road Map (EGRM)

Monday 10th March 2014

Attendees

Dr	Ola	Blixt	University of Copenhagen NTNU - Norw. Univ. of Science and Technol.
Professor	Bjorn	Christensen	UCPH
Professor	Henrik	clausen	Structural and Fonctional Glycobiology Unit, University of Lille
Professor	Philippe	Delannoy	University of Manchester
Dr	Claire	Doherty	University of Exeter
Professor	Stephen	Eichhorn	John Innes Centre
Professor	Rob	Field	University of Helsinki
Professor	Jukka	Finne	University fo Manchester
Professor	Sabine	Flitsch	University of Bristol
Dr	Carmen	Galan	Leiden University Medical Center
Dr	Cornelis	Hokke	University of Copenhagen
Professor	Ole	Hundsgaul	NUI Galway
Professor	Lokesh	Joshi	University of Gothenburg
Dr	Niclas	Karlsson	GALAB Laboratories GmbH
Dr	Jürgen	Kuballa	University of Zagreb
Professor	Gordan	Lauc	Euroglycoforum, Manchester.UK
Dr	Tony	Merry	University of Milano-Bicocca
Professor	Francesco	Nicotra	University of Copenhagen
Professor	Monica	Palcic Pilar-	
Professor	Amelia	Rauter	University Lisbon
Dr	Niels	Reichardt	CICBiomaGUNE
Professor	Pauline	Rudd	PI Max Planck Institute of Colloids and Interfaces
Professor	Peter	Seeberger	
Dr	William	Willats	University of Copenhagen

Dr Robert Woods NUIG / University of Georgia

Agenda 19.00 – **Sunday 9th**
23.00 **March**

SUNDAY: Informal get together reception

**MONDAY: CARLSBERG RESEARCH CENTER AUDITORIUM, Gamle
Carlsberg Vej 4**

Objectives of the workshop, purpose of the roadmap	9.00 –	Monday 10th March
	10.00	
Overall structure of roadmap (<i>a first draft will be circulated before the meeting</i>)	10.00 –	
	11.00	
<i>Break</i>	10.30 –	
	11.00	
Focussed discussions on current state-of-the-art	11.00 –	
	13.00	
<i>Lunch</i>	13.00 –	
	14.30	
Focussed discussions on applications in Glycoscience	14.00 –	
	15.00	
<i>Break</i>	15.30 –	
	16.00	
Decisions on finalising roadmap; key recommendations; summary	16.00 –	
	18.30	
<i>Dinner in Carlsberg Museum and Discussion</i>	19.00 –	
	22.00	

Delegates Leave **Tuesday**
11th March

Annex 2

Financial report

Total expenditure for

- Travel € 4,874
- Accommodation €4,134
- Meals €2,842
- Room hire €1,650
- Local administrative costs €1,400

Total €14,900