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### **APPOINTMENT**

**2000-present**      **Assistant Professor** of Medicinal Chemistry and Natural Products, School of Pharmacy, University of North Carolina at Chapel Hill, Chapel Hill, NC  
**1999-2000**        **Research Scientist**, Biology Department, Massachusetts Institute of Technology, Cambridge, MA  
**1998-2000**        **Research Fellow**, Molecular Medicine Unit, Beth Israel Hospital, Boston, MA

### **TRAINING**

**1993-1999**        **Postdoctoral Research Associate**  
Department of Biology, Massachusetts Institute of Technology  
Cambridge, MA 02139  
*Mentor:*            Professor Robert D. Rosenberg

**1989-1993**        **Ph.D. in Medicinal Chemistry and Natural Products**  
College of Pharmacy, The University of Iowa, Iowa City, Iowa.  
*Thesis Advisor:*    Professor Robert J. Linhardt

**1984-1987**        **M.S. in Biochemistry**, Nankai University, Tianjin, China.  
**1980-1984**        **B.S. in Chemistry**, Nankai University, Tianjin, China.

### **FUNDING**

#### ***Currently funded***

- 1) National Institute of Allergy/Infectious Diseases, R01 AI50050-01, July, 2001 to May, 2006. Project title: "Specificity of Heparan Sulfate for Herpes Infection". (Principal Investigator) direct cost \$625,000 for five years, 40% effort.
- 2) American Heart Association Mid-Atlantic Affiliate, grant-in-aid 0355800U, July 1 of 2003 to June 30 of 2005. Project title: "Understanding the biosynthesis of anticoagulant heparan sulfate". (Principal Investigator) direct cost \$120,000 for two years, 10% effort.

- 3) Pharmacy Foundation of North Carolina, seed grant, Feb. 1 to Dec. 31, 2004. Project title: "Investigation of the Molecular Mechanism of the Biosynthesis of Anticoagulant Heparan Sulfate". (Principal Investigator) direct cost \$9,500.

*Serve as a sponsor for graduate student fellowship*

- 1) National Institute of Allergy/Infectious Diseases, R01 AI50050S1, June 2004 to May 2005. Project title: "Specificity of Heparan Sulfate for Herpes Infection". A supplement fellowship to support Tanya Scarlett. Direct cost \$25,048.
- 2) American Heart Association, MidAtlantic Affiliate, July 2005 to June 2007. Project title: "Understanding the substrate recognition mechanism of heparan sulfate 3-O-sulfotransferase". A predoctoral fellowship to support Ding Xu. Direct cost \$40,000.

*Pending applications*

- 1) National Institute of Allergy/Infectious Diseases, 2R01AI050050-05A1, pending. Project title: "Structural specificity of heparan sulfate for herpes infection" (Principal Investigator). Priority score is **124 and 4.1 percentile**. Proposed budget: \$250,000/yr direct cost for five years.
- 2) National Heart, Lung and Blood Institute, 1R01HL085642-01. Project title: "Structural and functional analysis of heparan sulfate biosynthetic enzymes". (Principal Investigator) Proposed budget: \$250,000/yr direct cost for five years.

**HONORS AND AWARDS**

- 1996-1998** Postdoctoral Fellowship from American Heart Association Massachusetts and Rhode Island Affiliates, presented to outstanding physicians and scientists engaging in cardiovascular research.
- 1991-1993** Predoctoral Fellowship from American Heart Association Iowa Affiliates, presented to outstanding M.D. and Ph.D. candidates engaging in cardiovascular research.

**LIST OF PUBLICATIONS**

*A. Peer-reviewed publications at UNC-CH (\* denotes corresponding author)*

1. McDowell, L.M., Frazier, B., Studelska, D.R., Giljum, K., Chen, J., **Liu, J.**, Yu, K., Ornitz, D.M., and Zhang, L.\* (2006) Inhibition or activation of Apert syndrome FGFRs (S252W) signaling by specific glycosaminoglycans *J. Biol. Chem.* In press.
2. Duncan, M., Liu, M., Fox, C. and **Liu, J.\*** (2006) Characterization of the N-Deacetylase Domain from the Heparan Sulfate N-Deacetylase/N-Sulfotransferase 2 *Biochem. Biophys. Res. Commun.* 339: 1232-1237.

3. Eva Muñoz, Ding Xu, Fikri Avci, Melissa Kemp, **Jian Liu**, Robert J. Linhardt\* (2006) Enzymatic synthesis of heparin related polysaccharide on sensor chips: Rapid screening of heparin-protein interactions *Biochem. Biophys. Res. Commun.* 339:597-602.
4. Jinghua Chen, Fikri Y. Avci, Eva M. Muñoz, Lynda M. McDowel, Miao Chen, Lars C. Pedersen, Lijuan Zhang, Robert J. Linhardt, and **Jian Liu\*** (2005) Enzymatic redesigning of biologically active heparan sulfate *J. Biol. Chem.* 280: 42817-42825.
5. Gong, Y., Duvvuri, M., Duncan, M., **Liu, J.** and Krise, J.P.\* (2005) Niemann-pick C1 protein facilitates the efflux of the anticancer drug doxorubicin from cells according to a novel vesicle-mediated pathway *J. Pharmacol. Exp. Ther.* in press.
6. Jinghua Chen and **Jian Liu\*** (2005) Characterization of the Structure of Antithrombin-binding Heparan Sulfate Generated by Heparan Sulfate 3-O-Sulfotransferase 5 *Biochim. Biophys. Acta* 1725:190-200
7. Vaibhav Tiwari, Christian Clement, Ding Xu, Perry M. Scanlan, Veeral Seth, Gary Chung, Devanand Kowlessur, Tibor Valyi-Nagy, Beatrice Y.J.T. Yue, **Jian Liu**, and Deepak Shukla\* (2005) Entry of HSV-1 into primary cultures of corneal fibroblasts is mediated by HVEM and 3-O-S HS but not nectin-1. *Invest. Ophthalmol. Vis. Sci.* submitted
8. Vaibhav Tiwari, Christian Clement, Myung-Jin Oh, **Jian Liu**, Beatrice, Yue, Deepak Shukla\* (2005) Cell-to-cell fusion in cultured corneal fibroblasts is induced by herpes simplex virus glycoproteins gB, gD, gH-gL and 3-O-sulfated heparan sulfate *J. Gen. Virol.* submitted.
9. Ding Xu, Vaibhav Tiwari, Guoqing Xia, Christian Clement, Deepak Shukla and **Jian Liu\*** (2005) Characterization of heparan sulphate 3-O-sulphotransferase isoform 6 and the role in assisting the entry of herpes simplex virus, type 1. *Biochem. J.*385: 451-459.
10. Andrea Moon, Suzanne C. Edavettal, Joe M. Krahn, Eva M. Munoz, Masahiko Negishi, Robert J. Linhardt, **Jian Liu\***, and Lars C. Pedersen (2004) Structural analysis of the sulfotransferase (3-OST-3) involved in the biosynthesis of an entry receptor of herpes simplex virus 1. *J. Biol. Chem.* 279: 45185-45193 (Cover of October 22 issue).
11. Atsuko Negishi, Jinghua Chen, Douglas McCarty, Jude Samulski, **Jian Liu\***, and Richard Superfine\* (2004) Analysis of the interaction of heparan sulfate and adeno-associated virus by atomic force microscopy. *Glycobiology* 14: 969-977.
12. Suzanne C. Edavettal, Karen A. Lee, Masahiko Negishi, Robert J. Linhardt, **Jian Liu\***, and Lars C. Pedersen (2004) Crystal structure and mutational analysis of heparan sulfate 3-O-sulfotransferase isoform 1. *J. Biol. Chem.* 279: 25789-25797.

13. Suzanne C. Edavettal, Kevin Carrick, Ruchir Shah, Lars C. Pedersen, Alex Tropsha, R. Marshall Pope, and **Jian Liu\*** (2004) A conformational change of heparan sulfate 3-*O*-sulfotransferase induced by binding to heparan sulfate. *Biochemistry* 43: 4680 - 4688.
14. Vaibhav Tiwari, Christain Clement, Michael B. Duncan, Jinghua Chen, **Jian Liu**, and Deepak Shukla\* (2004) A role of 3-*O*-sulfated heparan sulfate in cell fusion induced by herpes simplex virus type-1. *J. Gen. Virol.* 85: 805-809.
15. Michael B. Duncan, Jinghua Chen, Jeffrey Krise and **Jian Liu\*** (2004) The contribution of heparan sulfate 3-*O*-sulfotransferase isoform 5 to the biosynthesis of anticoagulant heparan sulfate. *Biochim. Biophys. Acta* 1671: 34-43.
16. Jinghua Chen, Michael B. Duncan, Kevin Carrick, R. Marshall Pope, and **Jian Liu\*** (2003) Biosynthesis of 3-*O*-sulfated heparan sulfate: unique substrate specificity of heparan sulfate 3-*O*-sulfotransferase isoform 5. *Glycobiology* 13: 785-794.
17. Guoqing Xia, Jinghua Chen, Vaibhav Tiwari, Wujian Ju, Jing-pin Li, Anders Malmström, Deepak Shukla, **Jian Liu\*** (2002) Heparan sulfate 3-*O*-sulfotransferase isoform 5 generates both an antithrombin-binding site and an entry receptor for herpes simplex virus-1. *J. Biol. Chem.* 277: 37912-37919.
18. **Jian Liu\***, Zach Shriver, R. Marshall Pope, Suzanne C. Thorp, Michael B. Duncan, Ronald J. Copeland, Christina S. Raska, Keiichi Yoshida, Roselyn J. Eisenberg, Gary Cohen, Robert J. Linhardt, and Ram Sasisekharan (2002) Characterization of a heparan sulfate octasaccharide that binds to herpes simplex viral type 1 glycoprotein D. *J. Biol. Chem.* 277: 33456-33467.
19. Myette JR, Shriver Z, **Liu J**, Venkataraman G, Rosenberg R, Sasisekharan R\* (2002) Expression in *Escherichia coli*, purification and kinetic characterization of human heparan sulfate 3-*O*-sulfotransferase-1. *Biochem. Biophys. Res. Commun.* 290: 1206-1213.
20. Marshall Pope, Christina S. Raska, Suzanne C. Thorp and **Jian Liu\*** (2001) Analysis of heparan sulfate oligosaccharides by nanoelectrospray ionization mass spectrometry. *Glycobiology* 11: 505-513.

### ***B. Peer-reviewed publications during postdoctoral and graduate training***

1. Maria Hernaiz, **Jian Liu**, Robert D. Rosenberg, and Robert J. Linhardt (2000) Enzymatic modification of heparan sulfate on a biochip promotes its interaction with antithrombin III. *Biochem. Biophys. Res. Commun.* 276: 292-297.
2. Lijuan Zhang, David L. Beeler, Roger Lawrence, Mirosław Lech, **Jian Liu**, Joseph C. Davis, Zachary Shriver, Ram Sasisekharan, and Robert D. Rosenberg (2001) 6-*O*-Sulfotransferase-1 represents a critical enzyme in the anticoagulant heparan sulfate biosynthetic pathway. *J. Biol. Chem.* 276: 42311-42321.

3. Deepak Shukla¶, **Jian Liu**¶, Peter Blaiklock, Nicholas W. Shworak, Xiaomei Bai, Jeffrey D. Esko, Gary H. Cohen, Roselyn J. Eisenberg, Robert D. Rosenberg and Patricia G. Spear (1999) A novel role for 3-*O*-sulfated heparan sulfate in herpes simplex virus 1 entry. *Cell* 99: 13-22.(¶Both authors contributed equally to this work.)
4. **Jian Liu**, Zach Shriver, Peter Blaiklock, Keiichi Yoshida, Ram Sasisekharan, and Robert D. Rosenberg (1999) Heparan sulfate D-glucosaminyl 3-*O*-sulfotransferase 3A sulfates *N*-unsubstituted glucosamine. *J. Biol. Chem.* 274: 38155-38162.
5. **Jian Liu**, Nicholas W. Shworak, Pierre Sinay, John J. Schwartz, Lijuan Zhang, Linda M.S. Fritze and Robert D. Rosenberg (1999) Expression of heparan sulfate D-glucosaminyl 3-*O*-sulfotransferase isoforms reveals novel substrate specificities. *J. Biol. Chem.* 274: 5185-5192.
6. Nicholas W. Shworak, **Jian Liu**, Lorin M. Petros, Neal G. Copeland, Nancy A. Jenkins and Robert D. Rosenberg (1999) Diversity of the extensive heparan sulfate D-glucosaminyl 3-*O*-sulfotransferase (3-OST) multigene family. *J. Biol. Chem.* 274: 5170-5184.
7. Lijuan Zhang, Keiichi Yoshida, **Jian Liu** and Robert D. Rosenberg (1999) Anticoagulant heparan sulfate precursor structures in F9 embryonic carcinoma cells. *J. Biol. Chem.* 274: 5681-5691.
8. Masashi Kobayashi, Geetha Sugumaran, **Jian Liu**, Nicholas W. Shworak, Jeremiah E. Silbert, and Robert D. Rosenberg (1999) Molecular cloning and characterization of a human uronyl 2-sulfotransferase that sulfates iduronyl and glucuronyl residues in dermatan/chondroitin sulfate. *J. Biol. Chem.* 274: 10474-10480.
9. Lijuan Zhang, John J. Schwartz, Joseph Miller, **Jian Liu**, Linda M.S.Fritze, Nicholas W. Shworak, Robert D. Rosenberg (1998) The retinoic acid and cAMP-dependent up-regulation of 3-*O*-sulfotransferase-1 leads to a dramatic augmentation of anticoagulant active heparan sulfate biosynthesis in F9 embryonal carcinoma cells. *J. Biol. Chem.* 273: 27998-28003.
10. Nicholas W. Shworak, **Jian Liu**, Linda M.S. Fritze, John J. Schwartz, Lijuan Zhang, Logear, D. and Robert D. Rosenberg (1997) Molecular cloning and expression of mouse and human cDNAs encoding heparan sulfate D-glucosaminyl 3-*O*-sulfotransferase. *J. Biol. Chem.* 272: 28008-28019.
11. **Jian Liu**, Nicholas W. Shworak, Linda M.S. Fritze, Jay M. Edelberg and Robert D. Rosenberg (1996) Purification of heparan sulfate D-glucosaminyl 3-*O*-sulfotransferase. *J. Biol. Chem.* 271: 27072-27082.
12. Nicholas W. Shworak, Linda M.S. Fritze, **Jian Liu**, Lynne D. Butler and Robert D. Rosenberg (1996) Cell-free synthesis of anticoagulant heparan sulfate reveals a limiting converting activity that modifies an excess precursor pool. *J. Biol. Chem.* 271: 27063-27071.

13. Ghamartaj Hossein, **Jian Liu** and Ariane I. De Agostini (1996) Characterization and hormonal modulation of anticoagulant heparan sulfate proteoglycans synthesized by rat ovarian granulosa cells. *J. Biol. Chem.* 271: 22090-22099.
14. **Jian Liu**, Umesh R. Desai, Xue-Jun Han, Toshihiko Toida and Robert J. Linhardt (1995) Strategy for the sequence analysis of heparin. *Glycobiology* 5: 765-774.
15. Sylvia Collic-Jouault, Nicholas W. Shworak, **Jian Liu**, Ariane I. De Agostini and Robert D. Rosenberg (1994) Characterization of a cell mutant specifically defective in the synthesis of anticoagulant active heparan sulfate. *J. Biol. Chem.* 271: 24953-24958.
16. Nicholas W. Shworak, Motoaki Shirakawa, Sylvia Collic-Jouault, **Jian Liu**, Richard C. Mulligan, Louis K. Birinyi and Robert D. Rosenberg (1994) Pathway-specific regulation of the biosynthesis of anticoagulant active heparan sulfate. *J. Biol. Chem.* 269: 24941-24952.
17. Y. S. Kim, **J. Liu**, X.J. Han, A. Pervin and R. J. Linhardt (1994) Analysis of fluorescently labeled sugars by reversed-phase ion-pairing high performance liquid chromatography. *J. Chromatogr. Sci.* 33: 162-167.
18. **Jian Liu**, Azra Pervin, Cindy M. Gallo, Umesh R. Desai, Case VanGorp and Robert J. Linhardt (1994) New approaches for the preparation of hydrophobic heparin. *J. Pharmaceut. Sci.* 83: 1034-1039.
19. Robert J. Linhardt, Umesh Desai, **Jian Liu**, Debra Hoppensteadt and Jawed Fareed (1994) Low molecular weight dermatan sulfate as an antithrombotic agent: Structure activity relationship studies. *Biochem. Pharmacol.* 47: 1241-1252.
20. Kenan Gu, **Jian Liu**, Azra Pervin and Robert J. Linhardt (1993) Comparison of the activity of two chondroitin AC lyases on dermatan sulfate. *Carbohydr. Res.* 244: 369-377.
21. Robert J. Linhardt, Ali Al-Hakim, **Jian Liu**, Debra Hoppensteadt, Jawed Fareed, Giuseppe Mascellani, and Pietro Bianchini (1991) Structure features of dermatan sulfates and their relationship to anticoagulant and antithrombotic activities. *Biochem. Pharmacol.* 42: 1609-1619.
22. Youhan Xu, **Jian Liu**, Suipo Zhang and Lisheng Liu (1987) The effect of berbamine derivatives on activated  $\text{Ca}^{2+}$ -stimulated  $\text{Mg}^{2+}$ -dependent ATPase in erythrocyte membranes. *Biochem. J.* 248: 985-988.
23. Fayi Zhang, Yibao Zhang, **Jian Liu** and Xuezhuang Zhao (1986) Ascorbic acid oxidation reaction-kinetics of oxidation by molecular oxygen. *WuliHuaxue Xuebao* 2: 335-341 (in Chinese).

*C. Peer-reviewed review article at UNC*

1. **Jian Liu\*** and Suzanne C. Thorp (2001) Cell surface heparan sulfate and the roles in assisting viral infections. *Med. Res. Rev.* 22:1-25.

#### ***D. Peer-reviewed review articles at postdoctoral and predoctoral training***

1. Robert D. Rosenberg, Nicholas W. Shworak, **Jian Liu**, John J. Schwartz, and Lijuan Zhang (1997) Heparan sulfate proteoglycans of the cardiovascular system: specific structures emerge but how is synthesis regulated? *J. Clin. Invest.* 99: 2062-2070.
2. Robert J. Linhardt, **Jian Liu** and Xue-jun Han (1993) Mapping and sequencing of oligosaccharides by electrophoresis. *Trends Glycosci. Glycotechnol.* 5: 181-192.

#### ***E. Refereed book chapters***

1. Fikri Y. Avci, Paul L. DeAngelis, **Jian Liu**, and Robert J. Linhardt\* (2006) Enzymatic synthesis of glycosaminoglycans: improving on nature, in *Frontiers in Carbohydrate Chemistry*, in press.
2. **Jian Liu\*** and Robert D. Rosenberg (2001) Heparan sulfate D-glucosaminyl 3-O-sulfotransferase, in *Handbook of Glycosyltransferases and Their Related Genes* (N. Taniguchi and M. Fukuda Eds.) Springer-Verlag, Tokyo pp 475-483. (Book Chapter)
3. Robert J. Linhardt, Ali Al-Hakim and **Jian Liu** (1991) Acidic polysaccharides: Their modification and potential uses, in *Biotechnology and Polymers* (C. G. Gebelein Ed.) Plenum Press, New York, 155-165. (Book Chapter)

#### **INVITED LECTURES**

1. National Institute of Environmental Health Science, Research Triangle Park, April 2001. Title “The role of heparan sulfate in assisting viral infections”.
2. American Association for Pharmaceutical Sciences, Denver, Colorado, October 2001. Title “Heparan sulfate: a potential new receptor for gene delivery”.
3. Virginia Commonwealth University, Richmond, Virginia, May 2002. Title “Specificity of heparan sulfate in assisting herpes simplex viral infection”.
4. Georgia State University, Atlanta, Georgia, October 2003. Title: “Cell surface heparan sulfate: from an anticoagulant to a viral receptor.”
5. Rensselaer Polytechnic Institute, Troy, New York, October 2003. Title: “Heparan sulfate: from an anticoagulant to a viral receptor”.

6. University of Arkansas, Little Rock, Arkansas, April 2004. Title: "The biological functions and the fine structures of heparan sulfate".
7. University of Illinois at Chicago, Chicago, Illinois, September 2004. Title: "Investigation of the structural and functional relationship of heparan sulfate".
8. University of Iowa, Iowa City, IA, February 2006. Title: "Enzymatic synthesis of anticoagulant drugs".

#### ***Oral Presentations at Professional Meetings***

1. Proteoglycan Gordon Conference, Andover, NH, July 2002. Title: "Heparan sulfate 3-*O*-sulfotransferase isoform 5 generates both an antithrombin-binding site and an entry receptor for herpes simplex virus-1".
2. Proteoglycan Gordon Conference, Andover, NH, July 2004. Title: "Crystal structure and mutational analysis of heparan sulfate 3-*O*-sulfotransferase isoform 1".

#### **POSTERS PRESENTED AT PROFESSIONAL MEETINGS**

1. International Herpes Workshop, Madison, WI, July, 2003. Title: "Characterization of a heparan sulfate octasaccharide that binds to herpes simplex viral type 1 glycoprotein D".
2. Proteoglycan Gordon Conference, Andover, NH, July, 2002. Title: "Heparan sulfate 3-*O*-sulfotransferase isoform 5 generates both an antithrombin-binding site and an entry receptor for herpes simplex virus-1".
3. European Proteoglycan Gordon Conference (presented by Suzanne Edavettal), Perma, Italy, September, 2003. Title: "A conformational change of heparan sulfate 3-*O*-sulfotransferase induced by binding to heparan sulfate".
4. Proteoglycan Gordon Conference, Andover, NH, July, 2004. Title: "Crystal structure and mutational analysis of heparan sulfate 3-*O*-sulfotransferase isoform 1".
5. International Herpes Workshop, Reno, NV, July, 2004. Title: "Characterization of heparan sulphate 3-*O*-sulphotransferase isoform 6 and the role in assisting the entry of herpes simplex virus, type 1".
6. US/Japan Glycoconference, Honolulu, HI, November, 2004. Title: "Structural analysis of the sulfotransferase (3-OST-3) involved in the biosynthesis of an entry receptor of herpes simplex virus 1".
7. US/Japan Glycoconference (presented by Jinghua Chen), Honolulu, HI, November, 2004. Title: Determination of the structure of anticoagulant heparan sulfate generated by 3-*O*-sulfotransferase 5".

