CURRICULUM VITAE

PERSONAL INFORMATION

Peter Cecil Loewen

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Winnipeg, Manitoba, Canada, R3V 1B8
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Citizenship: Canadian
Date of Birth: 10 January 1946
Place of Birth: Calgary, Alberta

POST-SECONDARY EDUCATION

1966	B.Sc.	University of Alberta
1969	Ph.D.	University of Alberta (supervisor Dr. R.K. Brown)

EMPLOYMENT HISTORY

Professional Experience:

1969-1970	NRC Postdoctoral Fellow, Department of Biochemistry, University of Geneva, Switzerland, Dr. A. Tissiéres
1970-1971	NRC Postdoctoral Fellow, Departments of Biology and Chemistry, Massachusetts Institute of Technology, Dr. H.G. Khorana
1971-1973	Research Associate, Departments of Biology and Chemistry, Massachusetts Institute of Technology, Dr. H.G. Khorana
1973 -1976	Assistant Professor, Department of Microbiology, U. of Manitoba
1976	Tenure granted
1976 -1984	Associate Professor, Department of Microbiology, U. of Manitoba
1984 -	Professor, Department of Microbiology, University of Manitoba
1984 -1985	Associate Dean of Science, University of Manitoba
1985 - 2012	Head, Department of Microbiology, University of Manitoba
2013 - 2022	Associate Dean of Science, University of Manitoba
2023	Professor Emeritus (retired)

AWARDS/HONOURS

1966	Dean's Gold Medal in Science
1967-1969	National Research Council Bursary
1968-1969	Izaac Killam Memorial Fellowship
1969-1971	NRC Postdoctoral Fellowship
2001	Roche Diagnostic/Canadian Society of Microbiologists Award
2003-2017	Canadian Research Chair in Protein Chemistry

GRANTS

Operating

1973-1976	NRC: Determination of the DNA sequence (a) of the repetitious ends of T7 DNA and (b) around the λ attachment site. $10,000/$10,000/$11,700
1976-1979	NSERC: Determination of the DNA sequence (a) of the repetitious ends of T7 DNA and (b) around the λ attachment site. $11,700/$12,000/$13,008
1979-1982	NSERC: Nucleotide sequence analysis of T7DNA; Synthesis of the aminoacyl stem of yeast phenylalanine tRNA; coenzyme A nucleotides in *E. coli* metabolism $13,788/$15,000/$16,470
1982-1985	NSERC: Studies on catalase gene regulation and bacterial metabolism in the presence of ascorbic acid $23,000/$24,380/$25,599
1985-1988	NSERC: Studies on catalase gene expression $39,260/$37,690/$37,690
1988-1991	NSERC: Studies on the regulation of catalase gene expression in *E. coli* and *B. subtilis* $42,500/yr
1991-1994	NSERC: Studies on catalase gene expression in *Escherichia coli* $52,600/yr
1994-1998	NSERC: Expression and structure function studies of catalases HPI and HPII from *Escherichia coli* $60,000/yr
1998-2002	NSERC: Probing the structure and function of *Escherichia coli* catalases $61,500/$67,500/$71,033/$71,033/yr
2002-2007	NSERC: Probing the structure and function of *Escherichia coli* catalases. $84,120/yr
2003-2017	CRC: $200,000/yr
2007-2012	NSERC: Structural determinants of the oxidative stress response. $90,000/yr
2012-2017	NSERC Structure and function of oxidative defence systems. $48,000/yr

Equipment

1973	UM Research Board	$ 1,500
1975	NRC Centrifuge	$ 7,000
1977	UM Research Board	$ 1,150
1980	UM Research Board	$ 1,800
1983	UM Research Board	$ 1,083
1985	NSERC Oxygraph	$ 12,400
1988	UM Research Board	$ 2,500
1990	NSERC DNA Synthesizer	$ 27,819

1995	NSERC SGI Workstation	$ 26,148
2002	NSERC SGI Workstation	$ 18,400
2003	CFI CRC Equip & Renova.	$298,311
2007	CFI X-Ray Diffractometer	$999,282
2011	NSERC liquid robotics	$ 63,586

Other

1991-1992	NSERC International Collaborative Research Grant: $4825
1997-1999	NATO Travel Grant: $5000

TEACHING

University of Manitoba Credit Courses:

1973-1980; 1992-1998	60.235/2.235 Intermediate Biochemistry
1999-2002	60.236 Biochemistry I
1999-2013	60.237 Biochemistry II (now MBIO 2370)
1974-1979	60.339 Metabolic Biochemistry
1976-1984	2.453 Physical Biochemistry
1981-1990	60.240/2.240 Elements of Biochemistry
1981- 2001	60.345 Regulation in Biochemical Processes
1982	60.454 Energy Transduction
1978	60.343 Molecular Evolution
1995-1996	60.460 Molecular Genetics of Prokaryotes
1974,1976	60.710 Advanced Concepts in Molecular Biology
1975,1977,1979,1981	60.711 Advances in Microbial Genetics
1985-1989, 1996	60.713 Advanced Physiology of Bacteria
1985-1989	60.714 Advanced Pathogenic Microbiology & Immunol.
1985-1989	60.715 Subcellular Microbial Physiology
1999, 2001, -03, -05, -07	60.708 Biochemical Mechanisms (then MBIO 7080)
2011-2012	MBIO7010/7020/7030 Graduate Seminar in Microbiology
Summer Sess. 1974-81; 86	2.235/60.235 Intermediate Biochemistry

Summer NSERC Students Supervised:

B. Triggs	1983	A. Borys	1989
B. Hrabarchuk	1984	W. Thompson	1989
C. George	1984	T. Thorvaldson	1990
B. Doble	1987	R. O'Hagan	1990
T. Ijaz	1987	K. Shojania	1990
M. Zalnasky	1988	C. Scott	1994
T. Wang	1996	H. De La Cruz	1998
R. Pauls	1999	B. Peters	1999
B. Peters	2000	C. Miskiw	2003
R. deBlonde	2006	P. Mikal	2007
A. Abjullah	2009	E. Liu	2009

60.453 Project Course Students Supervised:

M. Haddow	1974-1975	K. Fowkes	1987-1988
R. Loewen	1975-1976	M. Williams	1987-1988
W. Bees	1975-1976	K. Ranson	1987-1988
N. Manji	1977-1978	M. Zalnasky	1988-1989
B. Triggs	1982-1983	E. Hsu	1989-1990
C. Cohen	1983-1984	K. Shojania	1989-1990
G. Yee	1983-1984	W. Tse	1989-1990
S. Danilition	1984-1985	C. Lowden	1990-1991
D. Smith	1984-1985	T. Dys	1990-1991
P. Sorby	1985-1986	C. Scott	1993-1994
A. Belkiri	1994-1995	R. Goswami	1996-1997
G. Bozak	1997-1998	P. Plett	1998-1999
A. Poeppl	2000-2001	P. Tsao	2001-2002
K. Combot	2011-2012		

Graduate Students Supervised and Thesis Titles:

M. Haddow M.Sc. 1978. Development of procedures for DNA sequencing of the attachment site of lambda bacteriophage.

W. Bees M.Sc. 1978. Partial characterization of the mode of inhibition of RNA polymerase by a mixed disulfide.

R.A.H. Furness M.Sc. 1980. The identification of p-aminobenzoylpoly- glutamates in extracts of *E. coli*.

H.E. Richter Ph.D. 1982. Studies on the effect of ascorbic acid on *E. coli* and its bacteriophage, T7.

M. Smolenski M.Sc. 1986. Cloning and partial characterization of three *katG* mutants from *Escherichia coli*.

B. Triggs-Raine Ph.D. 1987. Physical characterization of *katG*, encoding catalase HPI of *Escherichia coli*.

P.A. Sorby M.Sc. 1989. Cloning and partial characterization of *katE* encoding HPII catalase in *Escherichia coli*.

M.R. Mulvey Ph.D. 1990. Cloning and characterization of *katF*, a gene controlling a novel regulon in *Escherichia coli*.

T-G. Chen M.Sc. 1991. Cloning and characterization of *katG*, encoding catalase HPI, from catalase deficient mutants of *Escherichia coli*.

I. von Ossowski Ph.D. 1993. Characterization of *katE* and its product, catalase HPII, from *Escherichia coli,* by sequence analysis and site-directed mutagenesis.

K. Handel M.Sc. 1995. Identification of the promoter and transcription start site of the *katE* gene, encoding hydroperoxidase HPII, in *Escherichia coli*.

S. Sevinc Ph.D. 1997. Probing the structure and function of catalase HPII of *Escherichia coli*.

A. Hillar Ph. D. 1999. Comparative characterization and structure-function analyses of the catalase-peroxidases of *Escherichia coli* and *Mycobacterium tuberculosis*.

B. Hu. M.Sc. 1999. Role of residues on the proximal side of the heme in catalase HPII of *Escherichia coli*.

J. Strutinsky. M. Sc. 2000. Identification and genetic mappint of *perR*, a novel stationary phase gene that mediates oxidative stress protection in *Escherichia coli*.

A. Balakrishna. M. Sc. 2002. Structure function analysis of the catalase-peroxidase HPI from *Escherichia coli*.

K. Scott. Ph.D. 2003. Development and use of a *mer-lux* bioreporter for the measurement and characterization of bioavailable Hg(II) in defined media and aquatic environmental samples.

P. Chelikani, Ph. D. 2004. Probing the structure of *Escherichia coli* catalase HPII.

T. Deemagarn. M. Sc. Structure-function studies of the catalase-peroxidase BpKatG from *Burkholderia pseudomallei* 2004.

S. Louis, M. Sc. 2004. The role of key residues in the lateral channel of the *E. coli* catalase HPII.

R. Singh, Ph. D. 2006. Comparative study of catalase-peroxidases (KatGs).

T. Deemagarn, Ph.D. 2007. Structure analysis of KatG mutations impairing isoniazid resistance.

B. Wiseman, Ph.D. 2010. Structural and functional analysis of catalase-peroxidases.

V. Jha, Ph.D. 2011. Structural and functional characterization of catalase HPII of *Escherichia coli*.

M. Nandi, M.Sc. 2011. Isolation and structural characterization of a subset of yeast (*Saccharomyces cerevisiae*) peroxisomal proteins.

T. Guha, M.Sc. 2011. Purification of a subset of *Saccharomyces cerevisiae* peroxisomal proteins.

J. Chan, M.Sc. 2012. Functional investigation of a transcriptional regulator ptrA from *Pseudomonas chlororaphis* PA23.

Post-doctoral Fellows, Research Associates, Visiting Scientists

K. Sadana, Ph.D. Research Associate 1977-1981, NSERC
S. Zhang, Visiting Scholar, 1988-1989, Republic of China government.
Dr. D. Coombs, Dept of Biology, University of New Brunswick 1995-1996
Dr. X. Carpena, Research Associate, 2003-04, 2013, CRC
Dr. J. Barrett, Research Associate, 2003-04, CRC
Dr. M. Iranpour, Research Associate, 2003-07, CRC
Dr. L. J. Donald, Research Associate, 2004-15, CRC
Dr. B. Streit, Postdoctoral Fellow, 2010-2011, CRC

Technicians

J. Switala, 1982-2018
V. Spicer, 2014-15
J. Villanueva, 2004-14
M. Miller-Williams, 2004-10
A. Uppal, 2005-06
V. Larmour, 2005-12
V. Nunes-Halldorson, 2008-09

COMMITTEE AND ADMINISTRATIVE DUTIES

Departmental

Head, Department of Microbiology 1985-2012
Biochemistry Curriculum Committee 1973-2013
Joint Microbiology Chemistry Committee on Biochemistry 1978-2013
Department of Microbiology Review Committee 1983-1984

Faculty

Associate Dean of Science 1984-1985
Chair, Genetics Program Committee 1988-2007
Executive Committee, Faculty of Science 1979-1981
Department of Microbiology Head Review Committee 1977, 1982
Chair, Science Admissions Committee 1984-1985
Chair, Science Committee on Student Standing 1984-1985
Chair, Dept. of Applied Mathematics Review Committee 1984-1985
Chair, Dept. of Mathematics and Astronomy Review Committee 1984-1985
Chair, Applied Mathematics Promotion Committee 1984-1985
Chair, Statistics Promotion Committee 1984-1985
Chair, Earth Sciences Promotion Committee 1984-1985
Chair, Delta Marsh Field Station Review Committee 1984-1985
Chair, Earth Sciences Building Users Committee 1984-1985
Dean Selection Committee, Faculty of Science 1988-1989, 1994-95
Faculty of Science Promotion Committee 1988-1991
Faculty of Science Shops Advisory Committee 1986-1996
Faculty of Science Promotion Committee 1990-1995
Dean Review Committee, 2002
Associate Dean of Science 2013-2019

University

Science Representative on Pharmacy Faculty Council 1978-1989
Pharmacy Admissions Committee 1978-1988
University Parking Committee 1976-1979, 1989
University of Manitoba Budget Advisory Committee 1981-1984
Promotion Appeal Committee 1984
Faculty of Pharmacy Review Committee 1984-1986
Dean Selection Committee, Faculty of Arts 1986-1987
Dean Selection Committee, Faculty of Agriculture 1988-1989
Academic Review Committee of Senate 1988-1991
Libraries Promotion Committee 1988-1990

Research

Man. Health Research Commission, Grant Selection Committee 1984, 1985
Man. Health Research Commission, Chair, Grant Selection Committee 1986
Man. Health Research Commission, Chair, Scholarships Committee 1994-1995

University of Manitoba Research Grants Committee 1987-1993
University of Manitoba Research Development Fund 1994-1998
University Ethics in Research Committee 1989-1990
NSERC Grant Selection Committee (Molecular & Developmental Genetics) 1991-1994 (Chair NSERC GSC33 1994)
Associate Editor, Canadian Journal of Microbiology 1993-1997
Natural Sciences and Engineering Research Council 1997-1999
NSERC Committee on Communications 1999-2002
CFI Review Panel 2004-2006
NSERC Gerhard Herzberg Canada Gold Medal Selection Committee 2006-2007
NSERC Grant Selection Committee (32 - Cell Biology) 2008-2009
CFI MAC-5 2009
NSERC Herzberg Selection Committee 2010
CFI MAC-5 2012

Other and extracurricular

Microbiology Representative to the Faculty Association 1975-1984
Treasurer, Faculty Association 1976-1977; 1978-1979
Faculty Association Assessor of the Budget Advisory Committee 1979-1981
Faculty Association Assessor on the Board of Governors 1981-1982
Treasurer, Sigma Xi Research Society Chapter 1981-1984
Treasurer, Gimli Yacht Club, 1980-2009
Vice President, Manitoba Sailing Association, 1981-1996
President, Manitoba Sailing Association, 1997-2002
Treasurer, Canadian Yachting Association, 2002-2007
Treasurer, Pan American Sailing Federation, 1999-2007
Treasurer, Winnipeg Bach Festival, 1992-1996
Treasurer, Music Baroque Orchestra, 1997-2000
Director, Sport Manitoba, 2004-2007

External Reviews

External reviewer of the Graduate Program of the Department of Biological Sciences, University of Calgary, 1995
Chair, External Review Committee of the Department of Chemistry, University of Regina, 1997
External reviewer of the Department of Biological Sciences (Graduate Programs), University of Alberta, 1998
External reviewer of the Department of Biochemistry, Memorial University, 1998
External reviewer of the Department of Microbiology and Immunology, University of Saskatchewan, 2005
External reviewer of the Microbiology Program at MacDonald College, McGill, 2006

RESEARCH INTERESTS

The main goal of my research was the study of oxidative stress responses using the bacterium *Escherichia coli* as a model. In particular, the mechanisms by which catalases destroy highly reactive hydrogen peroxide before it damages cellular components were the main focus with two inter-related projects involving the structure-function characterization of catalases, HPI and HPII. Unfortunately, but inevitably, retirement approaches and research activity is in my lab came to a halt on March 31, 2018. What this will mean for my future scientific activities remains to be defined.

1. The principal catalase in *E. coli* is HPII, encoded by *katE*. While not essential for growth it plays a significant role in the survival of cells subjected to oxidative stress by hydrogen peroxide and during long-term dormancy. The sequence of *katE* has been determined revealing significant similarity to other known catalases and this will make information about the catalytic mechanism of HPII of relevance to the catalytic mechanism of other catalases. The crystal structure of HPII was determined and used as a model from which the roles of specific amino acids in the catalytic process and the binding of heme were predicted. These residues were changed individually using site-directed mutagenesis to verify the predictions and to provide information about their role in the mechanism of catalysis. Crystallography in conjunction with the protein crystallography group of Dr. I Fita at CSIC in Barcelona was an important aspect of the work.

2. The catalase-peroxidase KatG or HPI of *E. coli* is very similar to KatG from *M. tuberculosis* where it plays an important role in activating the widely used pro-drug isoniazid (INH) into an anti-tubercular drug. Mutants of *M. tuberculosis* that are resistant to the drug are a serious problem for disease control and more than half of these mutants have been found to have lost KatG activity. Initially, it was hoped that a better understanding of the role of HPI in this reaction would lead to the development of a new generation of antibiotics effective in the fight against tuberculosis. However, insights into the catalytic mechanism obtained from structure refinement of the closely related catalase-peroxidase KatG from *Burkholderia pseudomallei*, alone and in complex with INH, combined with a site-directed mutagenesis study have suggested that such a goal may not be possible. However, important insights into the catalytic mechanism of this fascinating multi-functional protein were gained from the studies. This work was part of an international collaboration also involving Dr. A. Ivancich's group at CNRS at Saclay and Dr. I. Fita's group at CSIC in Barcelona.

PUBLICATIONS

1. T.L. Richards and P.C. Loewen 1965. A preliminary investigation of solar radiation over the Great Lakes as compared to adjacent land areas. **Proc. Eighth Conf. on Great Lakes Research 13**: 278-282.

2. P.C. Loewen, W.W. Zajac and R.K. Brown 1969. Hydrogenolysis of LiAlH4-AlCl3 of an ether solution of norcamphor isobutylene ketal. **Can. J. Chem. 47**: 4059-4067.

3. P.C. Loewen, L.P. Makubu and R.K. Brown 1972. The influence of the 2-alkoxy group and C-5 substituents on the direction of reductive cleavage of 2-alkoxytetrahydrofurans by AlH2Cl in ether solution. **Can. J. Chem. 50**: 1502-1512.

4. P.C. Loewen and R.K. Brown 1972. 2-Aryloxytetrahydrofurans. Their reductive cleavage by ether solutions of AlH2Cl and their cleavage and rearrangement by ether solutions of AlCl3. **Can. J. Chem. 50**: 3639-3647.

5. J.H. van de Sande, P.C. Loewen and H.G. Khorana 1972. Studies on Polynucleotides CXVIII. A further study of ribonucleotide incorporation into DNA by DNA polymerase I of *E. coli*. **J. Biol. Chem. 247**: 6140-6148.

6. A. Panet, J.H. van de Sande, P.C. Loewen, H.G. Khorana, A.J. Raae, J.L. Lillehaug and K. Kleppe 1973. Studies on Polynucleotides CXXIII. Physical characterisation and simultaneous purification of bacteriophage T4 induced polynucleotide kinase, polynucleotide ligase and DNA polymerase. **Biochemistry 12**: 5045-5050.

7. P.C. Loewen and H.G. Khorana 1973. Studies on Polynucleotides CXXII. Dodecanucleotide sequence adjoining the CCA end of the tyrosine transfer RNA gene. **J. Biol. Chem. 248**: 3489-3499.

8. P.C. Loewen, T. Sekiya and H.G. Khorana 1974. Studies on Polynucleotides CXXVI. The nucleotide sequence adjoining the CCA end of the *E. coli* tyrosine transfer RNA gene. **J. Biol. Chem. 249**: 217-226.

9. P.C. Loewen 1974. Determination of the sequences of 18 nucleotides from the 5'-end of the 1-strand and 15 nucleotides from the 5'-end of the r-strand of T7 DNA. **Nucleic Acids Research 2**: 839-852.

10. H.G. Khorana, K.L. Agarwal, P. Besmer, H. Buchi, M.H. Caruthers, P.J. Cashion, M. Fridkin, E. Jay, K. Kleppe, R. Kleppe, A. Kumar, P.C. Loewen, R.C. Miller, K. Minamoto, A. Panet, U.L. RajBhandary, B. Ramamoorthy, T. Sekiya, T. Takeya and J.H. van de Sande 1976. Studies on Polynucleotides CXXXI. Total synthesis of the structural gene for the precursor of a tyrosine suppressor transfer from *E. coli*. General introduction. **J. Biol. Chem. 251**: 565-570

11. P.C. Loewen, R.C. Miller, A. Panet, T. Sekiya and H.G. Khorana 1976.Studies on polynucleotides CXXXVIII. Total synthesis of the structural gene for the precursor of a tyrosine suppressor transfer RNA from *E. coli*. Enzymatic joining of the chemically synthesized segments to form DNA duplexes corresponding to the nucleotide sequences 23 to 60 and 23 to 66. **J. Biol. Chem. 251**: 642-650.

12. R. Kleppe, T. Sekiya, P.C. Loewen, K. Kleppe, A.L. Agarwal, H. Buchi, P. Besmer, M.H. Caruthers, P.J. Cashion, M. Fridkin, E. Jay, A. Kumar, R.C. Miller, K. Minamoto, A. Panet, U.L. RajBhandary, B. Ramamoorthy, N. Siderova, T. Takeya, J.H. van de Sande and H.G. Khorana 1976. Studies on Polynucleotides CXLI. Total synthesis of the structural gene for the precursor of a tyrosine suppressor transfer RNA from *E. coli.* Enzymatic joining to form the total DNA duplex. **J. Biol. Chem. 251**: 667-675.

13. P.C. Loewen 1976. Novel nucleotides from *E. coli* isolated and partially characterized. **Biochem. Biophys. Res. Comm. 70**: 1210-1218.

14. G.R. Klassen, R.A. Furness and P.C. Loewen 1976. Inhibition of *E. coli* DNA dependent RNA polymerase by novel nucleotides DSI and DSII. **Biochem. Biophys. Res. Comm. 72**: 1056-1062.

15. P.C. Loewen 1976. Partial characterization of an endonuclease activity which appears in nuclease free T4 polynucleotide kinase. **Nucl. Acids Res. 3**: 3133-3141.

16. P.C. Loewen l977. Identification of a coenzyme A-glutathione disulfide (DSI), a modified coenzyme A disulfide (DSII) and a NADPH-dependent coenzyme A-glutathione disulfide reductase in E. coli. **Can. J. Biochem. 55**: 1019-1027.

17. J. Peeling, F.E. Hruska and P.C. Loewen 1978. Ribo-, 2'-deoxyribo- hybrid dinuclesoide monophosphates. Proton, magnetic resonance studies of 3', 5'- and 2',5'-uridylyl-2'-deoxythymidine. **Can. J. Chem. 56**: 522-529.

18. D.R. McNaughton, G.R. Klassen, P.C. Loewen and H.B. LéJohn 1978. Recharacterization of fungal dinucleoside polyphosphate (HS3). **Can. J. Biochem. 56**: 217-226.

19. P.C. Loewen 1978. Levels of coenzyme A-glutathione mixed disulfide in *Escherichia coli.* **Can. J. Biochem. 56**: 753-759.

20. K.L. Sadana and P.C. Loewen 1978. A rapid and efficient synthesis of ribonucleotides. **Tetrahedron Letters**, 5095-5098.

21. P.C. Loewen 1979. Levels of glutathione in *E. coli*. **Can. J. Biochem. 57**: 107-111.

22. W.C.H. Bees and P.C. Loewen 1979. Partial characterization of the mode of inhibition of *E. coli* RNA polymerase by the mixed disulfide, CoASSG. **Can. J. Biochem. 57**: 336-345.

23. P.C. Loewen 1981. Effect of glutathione deficiency on the pool of CoA-glutathione mixed disulfide in *Escherichia coli*. **Can. J. Biochem. 59**: 379-382.

24. W.P. Niemczura, F.E. Hruska, K.L. Sadana and P.C. Loewen 1981. Proton magnetic resonance study of nucleosides, nucleotides and dideoxynucleoside monophosphates containing a syn pyrimidine base. **Biopolymers 20**: 1671-1690.

25. H.E. Richter and P.C. Loewen 1981. Induction of catalase in *Escherichia coli* by ascorbic acid involves hydrogen peroxide. **Biochem. Biophys. Res. Comm. 100**: 1039-1046.

26. R.A.H. Furness and P.C. Loewen 1981. Detection of p-aminobenzoyl(γ- glutamates) using fluorescamine. **Anal. Biochem. 117**: 126-135.

27. K.L. Sadana, F.E. Hruska and P.C. Loewen 1981. A simplified strategy for the synthesis of dideoxyribonucleotide blocks. **Tetrahedron Letters 22**: 3367-3370.

28. H.E. Richter and P.C. Loewen 1982. Catalase synthesis in *Escherichia coli* is not controlled by catabolite repression. **Arch. Biochem. Biophys. 215**: 72-77.

29. H.E. Richter and P.C. Loewen 1982. Rapid inactivation of bacteriophage T7 by ascorbic acid is repairable. **Biochem. Biophys. Acta 697**: 25-30.

30. W.J.P. Blonski, F.E. Hruska, K.L. Sadana and P.C. Loewen 1983. Conformational studies of ribo-, 2'-deoxyribo- and arabinonucleotides by carbon 13 NMR. **Biopolymers 22**: 605-616.

31. P.C. Loewen and H.E. Richter 1983. Inhibition of sugar uptake by ascorbic acid in *Escherichia coli*. **Arch. Biochem. Biophys. 226**: 657-665.

32. P.C. Loewen, B.L. Triggs, G.R. Klassen and J.H. Weiner 1983. Identification and physical characterisation of a ColEl hybrid plasmid containing a catalase gene of *Escherichia coli*. **Can. J. Biochem. 61**: 1315-1321.

33. P.C. Loewen 1984. Isolation of catalase-deficient *Escherichia coli* mutants and genetic mapping of *katE*, a locus that affects catalase activity. **J. Bacteriol. 157**: 622-626.

34. P.C. Loewen and B.L. Triggs 1984. Genetic mapping of katF, a locus that with katE affects the synthesis of a second catalase species in *Escherichia coli*. **J. Bacteriol. 160**: 668-675.

35. P.C. Loewen 1985. Detection of p-aminobenzoylpoly(γ-glutamates) using fluorescamine. **Methods in Enzymology 122**: 330-333.

36. F.C. Wong, J.G. Spearman, M.A. Smolenski and P.C. Loewen 1985. Equine parvovirus: Initial isolation and partial characterization. **Can. J. Comp. Med. 49**: 50-54.

37. P.C. Loewen, B.L. Triggs, C.S. George and B.E. Hrabarchuk 1985. Genetic mapping of *katG*, a locus that affects the synthesis of the bifunctional catalase-peroxidase HPI in *Escherichia coli*. **J. Bacteriol. 162**: 661-667.

38. P.C. Loewen, J. Switala and B.L. Triggs-Raine 1985. Catalases HPI and HPII in *Escherichia coli* are induced independently. **Arch. Biochem. Biophys. 243**: 144-149.

39. P.C. Loewen and J. Switala 1986. Purification and characterization of catalase HPII from *Escherichia coli* K12. **Can. J. Biochem. & Cell Biol. 64**: 638-646.

40. B.L. Triggs-Raine and P.C. Loewen 1987. Physical characterization of *katG*, encoding catalase HPI of *Escherichia coli*. **Gene 52**: 121-128.

41. P.C. Loewen and J. Switala 1987. Multiple catalases in *Bacillus subtilis*. **J. Bacteriol. 169**: 3601-3607.

42. P.C. Loewen and J. Switala 1987. Purification of catalase-1 from *Bacillus subtilis*. **Biochem. Cell Biol. 65**: 939-947.

43. P.C. Loewen and J. Switala 1987. Genetic mapping of *katA*, a locus that affects the synthesis of catalase-1 in *Bacillus subtilis*. **J. Bacteriol. 169**: 5848-5851.

44. H.E. Richter, J. Switala and P.C. Loewen 1988. Effect of ascorbate on oxygen uptake and growth of *Escherichia coli* B. **Can. J. Microbiol. 34**: 822-824.

45. P.C. Loewen and J. Switala. 1988. Purification and characterization of spore-specific catalase-2 from *Bacillus subtilis*. **Biochem. Cell. Biol. 66**: 707-714.

46. B.L. Triggs-Raine, B.W. Doble, M.R. Mulvey, P.A. Sorby and P.C. Loewen. 1988. Nucleotide sequence of katG encoding catalase HPI of *Escherichia coli*. **J. Bacteriol. 170**: 4415-4419.

47. M.R. Mulvey, P.A. Sorby, B.L. Triggs-Raine and P.C. Loewen. 1988. Cloning and physical characterization of *katE* and *katF*, required for catalase HPII expression in *E. coli*. **Gene 73**: 337-345.

48. P.C. Loewen. 1989. Genetic mapping of *katB*, a locus that affects catalase 2 levels in *Bacillus subtilis*. **Can. J. Microbiol. 35**: 807-810.

49. J.T. Chiu, P.C. Loewen, J. Switala, R.B. Gennis & R. Timkovich. 1989. Proposed structure for the prosthetic group of the catalase HPII from *Escherichia coli*. **J. Am. Chem. Soc. 111**: 7046-7050.

50. M.R. Mulvey and P.C. Loewen. 1989. Nucleotide sequence of *katF* suggests KatF protein is a novel sigma transcription factor. **Nucl. Acids Res. 17**: 9979-9991.

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76. T. R. de Kievit, M. Nandi, A. K. Brassinga, P. C. Loewen, W. G. D. Fernando. *Pseudomonas* sp. DF41 biological control: keeping fungi and bacterial predators at bay. 2013. **Canadian Phytopathological Society**, Carmen, Manitoba, Canada, November, 20th, 2013. *T.R. de Kievit presenter

77. M. Nandi, P. C. Loewen, W. G. D. Fernando and T. R. de Kievit. Quorum sensing affects *Pseudomonas* sp. DF41 biocontrol through the regulator RfiA. 2013. **10th International Congress of Plant Pathology**, Beijing China, August 24-30, 2013.

78. M. Nandi, A. K. Brassinga, P. C. Loewen, W. G. D. Fernando, and T. R. de Kievit. The Role of Quorum Sensing in Biocontrol species, *Pseudomonas* DF41 and Its Interaction with The Predator *Caenorhabditis elegans*. 2014. **Canadian Society of Microbiologists**, June 17-20, Ottawa, Ontario, Canada. Poster number MCPC08.

79. M. Nandi, P. C. Loewen, and T. R. de Kievit. The Role of Quorum Sensing in *Pseudomonas* sp. DF41 biocontrol. 2014. **Prairie University Biology Symposium**, February 21-23, 2014 Winnipeg, Manitoba, Canada.

SUBMISSIONS TO DATA BASES

Sequence pre-GenBank

1.	1973	J. Biol. Chem. 248	12 bases at end of Tyr tRNA gene
2.	1974	J. Biol. Chem. 249	23 bases at end of Tyr tRNA gene

GenBank:

1.	1988	M21516	*E. coli katG*
2.	1989	Z14969	*E. coli katF* (*rpoS*)
3.	1990	X53001	*S. typhimurium katG*
4.	1991	M55161	*E. coli katE*
5.	2014	CP007410	*Pseudomonas brassicacareum* DF41 genome
6.	2014	CP007436	*Bacillus pumilus* MTCC B6033 genome
7.	2014	CP008696	*Pseudomonas chlororaphis* PA23 genome
8.	2014	CP009256	*Acinetobacter baumannii* AB031 genome
9.	2014	CP009257	*Acinetobacter baumannii* AB030 genome
10.	2016	CP012749	*Rhodococcus* sp. 008 genome
11.	2016	CP015203	*Rhodococcus* sp. 008 plasmid 1
12.	2016	CP015204	*Rhodococcus* sp. 008 plasmid 2
13.	2016	CP015205	*Rhodococcus* sp. 008 plasmid 3

Protein Data Base:

1.	1995	1IPH	HPII of *E. coli* at 2.8 Å
2.	1999	1QF7	H392Q of HPII of *E. coli*
3.	1999	1CF9	V169C of HPII of *E. coli*
4.	2000	1GG9	H128N of HPII of *E. coli*
5.	2000	1GGE	HPII of *E. coli* at 1.9 Å
6.	2000	1GGF	H128N of HPII of *E. coli* with H_2O_2
7.	2000	1GGH	H128A of HPII of *E. coli*
8.	2000	1GGJ	N201A of HPII of *E. coli*
9.	2000	1GGK	N201H of HPII of *E. coli*
10.	2002	1M7S	CatF of *P. syringae*
11.	2016 (2002)	5L05 (1MWV)	KatG of *B. pseudomallei*
12.	2003	1P7Y	D181A of HPII of *E. coli*
13.	2003	1P7Z	D181S of HPII of *E. coli*
14.	2003	1P80	D181Q of HPII of *E. coli*
15.	2003	1P81	D181E of HPII of *E. coli*
16.	2003	1QWL	KatA of *H. pylori* or HPC
17.	2003	1QWM	HPC with formate
18.	2003	1QWS	D181N of HPII of *E. coli*
19.	2004	1U2J	HPI of *E. coli* C-terminal domain $P2_12_12_1$
20.	2004	1U2K	HPI of *E. coli* C-terminal domain $I4_1$
21.	2004	1U2L	HPI of *E. coli* C-terminal domain P1
22.	2016 (2002)	5L02 (1X7U)	S324T of KatG of *B. pseudomallei*
23.	2004	1YE9	truncated variant of HPII of *E. coli*
24.	2016 (2005)	5SW4 (2B2Q)	BpKatG at pH 7.5

25.	2016 (2005)	5SW5 (2B2O)	BpKatG at pH 8.0
26.	2016 (2005)	5SW6 (2B2R)	BpKatG compound I
27.	2016 (2005)	5SX0 (2B2S)	BpKatG peracetate shifted to pH 7.5
28.	2006	2IQF	Compound I of HPC
29.	2016 (2006)	5SX3 (2FXG)	BpKatG at pH 4.5
30.	2016 (2006)	5SX6 (2FXH)	BpKatG at pH 6.5
31.	2016 (2006)	5SX7 (2FXJ)	BpKatG at pH 8.5
32.	2016 (2006)	5SX1 (2DV1)	D141E variant of BpKatG
33.	2016 (2006)	5SX2 (2DV2)	D141E variant of BpKatG at pH 8
34.	2007	2QLW	RhaU
35.	2007	2QLX	RhaU with rhamnose bound
36.	2016 (2010)	5SXQ (3N3N)	BpKatG with INH bound
37.	2016 (2010)	5SXR (3N3O)	BpKatG with NAD^+ bound
38	2016 (2010)	5SXS (3N3P)	BpKatG with AMP and INH bound
39	2016 (2010)	5SXT (3N3Q)	BpKatG S324T variant with INH bound
40	2016 (2010)	5SXW (3N3R)	BpKatG E198A variant
41	2016 (2010)	5SXX (3N3S)	BpKatG E198A variant with INH bound
42	2010	3P9P	I274V of KatE of *E. coli*
43	2010	3P9Q	I274C of KatE of *E. coli*
44	2010	3P9R	I274G of KatE of *E. coli*
45	2010	3P9S	I274A of KatE of *E. coli*
46	2010	3PQ2	I274C of KatE - Images 1-6
47	2010	3PQ3	I274C of KatE - Images 7-12
48	2010	3PQ4	I274C of KatE - Images 13-18
49	2010	3PQ5	I274C of KatE - Images 19-24
50	2010	3PQ6	I274C of KatE - Images 25-30
51	2010	3PQ7	I274C of KatE - Images 31-36
52	2010	3PQ8	I274C of KatE - Images 37-42
53	2011	3TTT	F413Y variant of *E. coli* KatE
54	2011	3TTU	F413Y/H128N variant of *E. coli* KatE
55	2011	3TTV	F413Y/T115A variant of *E. coli* KatE
56	2011	3TTW	F413E variant of *E. coli* KatE
57	2011	3TTX	F413K variant of *E. coli* KatE
58	2012	3UT2	KatG2 of *Magnaporthe grisea*
59	2012	4ENP	E530A variant of *E. coli* KatE
60	2012	4ENQ	E530D variant of *E. coli* KatE
61	2012	4ENR	E530I variant of *E. coli* KatE
62	2012	4ENS	E530Q variant of *E. coli* KatE
63	2012	4ENT	S234A variant of *E. coli* KatE
64	2012	4ENU	S234D variant of *E. coli* KatE
65	2012	4ENV	S234I variant of *E. coli* KatE
66	2012	4ENW	S234N variant of *E. coli* KatE
67	2012	4FGW	GPD1 of *S. cerevisiae*
68	2012	4HHH	Pea rubisco with ribulose-1,5-bisphosphate
69	2016 (2013)	5SYH (4KA5)	D141A variant of BpKatG
70	2016 (2013)	5SYI (4KA6)	D141A variant of BpKatG with INH bound
71	2016 (2013)	5SYJ (4KWQ)	D141A with INH soaked into crystal
72	2013	4MKV	Pea rubisco with abscisic acid bound

73	2016 (2013)	5SYK (4MVP)	BpKatG soaked in H_2O_2
74	2014	4QOL	*Bacillus pumilus* catalase (BPC)
75	2014	4QOM	BPC with pyrogallol bound
76	2014	4QON	BPC with catechol bound
77	2014	4QOO	BPC with resorcinol bound
78	2014	4QOP	BPC with hydroquinone bound
79	2014	4QOQ	BPC with guaiacol bound
80	2014	4QOR	BPC with chlorphenol bound
81	2016 (2014)	5SYL (4QZJ)	BpKatG with KCN bound
82	2016 (2014)	5SYU (4QZK)	E242Q variant of BpKatG
83	2016 (2014)	5SYV (4QZL)	N240D variant of BpKatG
84	2016 (2014)	5SYW (4QZN)	Q233E variant of BpKatG
85	2016 (2014)	5KSN (4QZO)	S324G variant of BpKatG
86	2016 (2014)	5SYX (4QZP)	W139F variant of BpKatG
87	2016	5KQ0	A290D variant of BpKatG
88	2016	5KQ2	A357D variant of BpKatG
89	2016	5KQ3	D141A/Q233E variant of BpKatG
90	2016	5KQ6	A359D variant of BpkatG
91	2016	5KQ7	D141A/Q233E/N240D variant of BpKatG
92	2016	5KQH	V293D variant of BpKatG
93	2016	5KQI	L326D variant of BpKatG
94	2016	5KQK	Q233E/N240D variant of BpKatG
95	2016	5KQN	H381S variant of BpKatG
96	2016	5KQQ	W153F variant of BpKatG
97	2016	5KSF	D141A variant of BpKatG with acetate
98	2016	5KSG	W153F variant of BpKatG with isoniazid bound
99	2016	5KSK	BpKatG treated with acetate
100	2016	5KSN	S324G variant of BpkatG with isoniazid bound
101	2016	5KT8	W139F variant of BpKatG with isoniazid bound
102	2016	5KT9	BpKatG treated with H_2O_2 and CO
103	2016	5TXQ	A143D variant of BpkatG
104	2017	5V2D	Lignostilbene dioxygenase of *P. brassicacaerum*
105	2017	6B9B	BpKatG with maltose
106	2017	6CAW	W95F variant of BpKatG
107	2017	6CC6	W202F variant of BpKatG
108	2017	6CDQ	W202F variant of BpKatG with INH bound
109	2017	6CEK	D141N variant of BpKatG
110	2017	6CFQ	D141N variant of BpKatG with INH bound
111	2018	6MPY	BpKatG crystallized with benzoyl hydrazide
112	2018	6MQ0	BpKatG crystallized with furoyl hydrazide
113	2018	6MQ1	BpKatG crystallized with ABTS
114	2018	6ND8	Rhodocetin-integrin complex with barium
115	2018	6ND9	Rhodocetin-integrin complex with calcium
116	2018	6NDA	Rhodocetin-integrin complex with cadmium
117	2018	6NDB	Rhodocetin-integrin complex with cobalt
118	2018	6NDC	Rhodocetin-integrin complex with chromium
119	2018	6NDD	Rhodocetin-integrin complex with manganese
120	2018	6NDE	Rhodocetin-integrin complex with prasedymium

121	2018	6NDF	Rhodocetin-integrin complex with strontium
122	2018	6NDG	Rhodocetin-integrin complex with yttrium
123	2018	6NDH	Rhodocetin-integrin complex with zinc
124	2019	6OOL	Ectodomain of mouse UNC5H2

PATENT

US 7,355,092 B2 Genetic vaccines for the production of chicken egg-yolk antibodies against *Escherichia coli* and other pathogens.

INVITED LECTURES

Western Branch of the Canadian Society of Microbiology. October 1985. Cloning and physical characterization of *katG* from *E. coli*.

Western Branch of the Canadian Society of Microbiology. October 1988. Physical characterization of *katF* as an alternate sigma transcription factor in *E. coli*.

Symposium on the Molecular Biology of Free Radical Scavenging Systems. Banbury Center, Cold Spring Harbour Laboratory. November 1990. Regulation of *katE* and *katF* expression in *E. coli*.

American Society for Microbiology Annual Meeting 1991. Symposium on Stationary Phase Differentiation in the Enterics. Characterization of *katF*, encoding a putative σ factor in *Escherichia coli*.

Albany Conference 1991 on Molecular & Cellular Responses to Oxygen. Regulation of *katF* expression in *E. coli*.

Massachusetts Institute of Technology, Department of Biology 1991. Regulation of *katF* expression in *E. coli*.

University of Massachusetts Medical School, Department of Molecular Genetics and Microbiology. 1992. Regulation of catalase synthesis in *E. coli*.

University of Saskatchewan, Department of Microbiology 1993 Catalases and peroxide sensitivity in *Escherichia coli*

American Society for Microbiology Annual Meeting 1994. Symposium on oxidative stress in bacteria. Determinants of peroxide resistance in *Escherichia coli*

International Conference on Biotechnology Research and Applications for Sustainable Development, Bangkok, Thailand, 1995. Probing the structure and function of catalase HPII of *E. coli*

University of British Columbia, Department of Biochemistry 1995 Probing the structure and function of catalase HPII of *E. coli*.

Centro D'Investigacion Y Desarrollo, Barcelona, Spain, 1996. Physiology of bacterial catalases.

Department of Chemistry, University of Manitoba, 1997. Novel structural features of catalase HPII

Department of Biochemistry, Queen's University, 1997. Probing the structure of *E. coli* catalase HPII.

Department of Biotechnology, Mahidol University, Thailand, 1999. Lecture 1. Catalase physiology and phylogeny: expected stress responses in an unexpected family tree. Lecture 2. Catalase structure and function: an old enzyme that is showing us new tricks.

Symposium on the Molecular Biology of Oxidative Stress. Banbury Center, Cold Spring Harbour Laboratory. 2000. Structure and function of bacterial catalases.

Biotechnology: Impacts and Trends. The 12th Annual Meeting of the Thai Society for Biotechnology. 2000. Modulation of the activity of catalase-peroxidase KatG by site directed mutagenesis.

Canadian Society of Microbiologists Annual Meeting. The Roche Diagnostics Award Lecture 2001. Physiology meets structure and function in catalase.

Mahidol University, Thailand, Department of Biotechnology, 2001. Physiology meets structure and function in catalase.

University of Saskatchewan, Department of Microbiology 2002. Catalase, an "old" enzyme that continues to surprise us.

University of Manitoba, Department of Chemistry 2003. Catalases, peroxidases, isonicotinic acid hydrazide and tuberculosis.

Centre Energie Atomique, Saclay, France, 2003. Catalase and peroxidase structures and tuberculosis.

University of Manitoba, Department of Medical Microbiology 2003. Catalase and peroxidase structures: a role in tuberculosis.

American Society for Microbiology Annual Meeting 2004 Evolution of oxidative stress response systems.

University of Manitoba, Department of Pharmacology 2007. Catalases, peroxidases, isoniazid and tuberculosis.

International Conference on Biological Inorganic Chemistry - XV, 2011, KatG: INH activation and catalase activity in a peroxidase environment.

University of Manitoba, Department of Medical Microbiology, 2014. Multifaceted catalases: from bioremediation to antibiotic activation.

Center Nationale de Research Scientifique, Marseilles, 2015, Multifaceted catalases: from bioremediation to antibiotic activation.

Departamento de Quimica e Bioquimica, University of Lisbon, 2016. Anti-tubercular pro-drug INH activation and H_2O_2 degradation by catalase-peroxidases share common reaction intermediates.

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