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### **EDUCATION:**

University of Alberta, Edmonton, Canada, B.S. in Chemistry, 1966 (with Distinction).  
Memorial University of Newfoundland, St. Johns, Canada, B.S. in Biology, 1968, First Class.  
University of Hawaii, Honolulu, Climatology, 1968.  
University of Wales, Swansea, Agricultural Climatology, 1969-70.  
University of Wyoming, Atmospheric Science, M.S., 1971. **Thesis:** "Ice Nuclei from Decomposing Tree Leaves," supervised by Dr. G. Vali.  
University of Wyoming, Atmospheric Science, Ph.D., 1974. **Dissertation:** "Biogenic Sources of Atmospheric Ice Nuclei," supervised by Dr. G. Vali.

### **WORK RESEARCH AND EXPERIENCE:**

1960-1963: Castor Advance, Castor, Alberta, Printer's Apprentice

1966-1968: Research Technician, Alberta Research Council, Alberta Hail Studies:  
Develop, install and maintain a precipitation and hail collection network over 10,000 square miles of Alberta farmland.

1969-1971: Research Assistant, Department of Atmospheric Science, University of Wyoming, Laramie: National Hail Research Experiment, Elk Mountain Orographic Cloud Studies, and Project METROMEX. Discovered biological ice nuclei, living and inanimate.

1971-1974: Scientist I, Department of Atmospheric Sciences, University of Wyoming, Laramie. Laboratory research into biogenic atmospheric ice nuclei with \$133,000/yr. research grant from the National Science Foundation (NSF).

1974-1975: National Center for Atmospheric Research (NCAR), Boulder, CO, Advanced Study Program Fellow. Original research into naturally occurring ice nucleants, conducted a two-month drought research and ice nuclei research project in the Sahel of Africa. Invited member of the

1975 US Navy HAYES Atlantic Fog Research Cruise. On-board aircraft scientist for NCAR Project DUSTSTORM.

1975-1976: National Research Council, Research Associate, NOAA/APCL, Boulder CO. Research into the structure and form of naturally occurring biological ice nucleants, aerosol composition studies, power plant plume studies. Development of techniques for the control of bacterial ice nucleants (i.e. frost damage) in crops, aerosol and ice nucleus research. Research on ski hill snowmaking with biological ice nuclei. This later was developed into SNOWMAX ski hill snowmaking additive by Kodak Inc.

1976-1978: Director, Mount Kenya Baseline Station Feasibility Study, Nairobi, Kenya. Directed a United Nations project studying the feasibility of building an atmospheric baseline monitoring station on Mount Kenya (15,000ft). Overall responsibility for the planning, field research, data analysis, personnel, accounting and reporting. Conducted surface and airborne research. Responsible for a staff growing from 3 up to 45 personnel when in the field. Project successful. Mt. Kenya Atmospheric Baseline Observatory constructed and put into operation at a later date.

1979: Scientist, WMO Project PEP, Valladolid, Spain. Airborne cloud physics research scientist studying the potential for seeding clouds for rain above central Spain.

1979-1991: Research Scientist, Cooperative Institute for Research in Environmental Science (CIRES), University of Colorado, Boulder, CO. Conducting research into the sources, nature, and control of biological ice nucleants in frost protection on plants, Arctic aerosols and Arctic climate and ice projects. Director, Special Operations Group conducting research projects for the US Government in remotes foreign locations.

1983-1984: Guest Editor, Geophysical Research Letters, Arctic Haze Special Issue.

1982-1996: Director, Arctic Gas and Aerosol Sampling Program (AGASP). Conceived, organized, arranged funding for, and directed the multi-\$ million, multi-national AGASP program. At its peak activity in March-April 1986 there were 5 aircraft and 185 personnel representing 8 government agencies and 13 Universities from 6 countries conducting coordinated Arctic Haze, ice and energy budget related measurements around the Arctic Ocean including off Svalbard, the USSR Arctic, Canadian Arctic Archipelago and off Alaska. Co-editor, Atmos. Environ., Special Issue, DGASP/AGASP, 1992-93.

1991-1998: Director, Mauna Loa Observatory (MLO), Hilo, Hawaii. Responsible for overall operations, staff, budget, data collection and data quality for MLO. Instrumental in the successful acquisition of a new main MLO building completed in 1997, five additional research buildings funded from outside NOAA, and a new 18 mile paved road to MLO with funds arranged through then Senator D. Inouye.

1998-2005: Director, Observatory and Global Network Operations, NOAA/GMD, Boulder, CO. Overall responsibility for the operations, budgets, and personnel at the five GMD Global Atmospheric Monitoring Stations (Barrow, AK; Mauna Loa, Hawaii; Samoa; Trinidad, Head, CA; and South Pole, Antarctica).

2005-2020: Deputy Director, NOAA Earth System Research Laboratory, Global Monitoring Division (GMD), Boulder, CO. GMD monitors the Earth's atmospheric composition related to climate forcing, ozone, and surface radiation with 100+ personnel, 130 global sampling sites, and an annual \$20 M budget.

2020-date: Senior Scientist, Cooperative Institute for Environmental Sciences (CIRES). Research on ozone, gas and oil field effluents, greenhouse gases, atmospheric ice nuclei.

### **HONORS, AWARDS AND CERTIFICATIONS:**

1962: Royal Canadian Air Cadet Flight Training Scholarship (Pilot License).

1963: Royal Canadian Air Cadet Exchange Scholarship to Israel, Guest of the Israeli Defense Forces (Air), summer 1963.

1964: Royal Lifesaving Society, Gold Medallion

1965-1966: Canadian Union of Student Exchange Scholarship to Memorial University, Newfoundland.

1968-1969: Rotary International Fellow, University of Wales, Swansea.

1969: British Union of Students Exchange with Russia- one month in Russia.

1971: Canadian Student Representative, Williamsburg International Assembly Williamsburg, Virginia, guest of the Rockefeller Foundation.

1972: Sigma Tau (Engineering Honorary)

1976-1979: Member, National Academy of Sciences Committee on Aerobiology

1981-89: US Representative on US-USSR Working Group 8; many trips to Russia.

1981: Certified Consulting Meteorologist Accreditation (American Meteorological Society Certification)

1983: Invited guest to China (one month, China supported) as a visitor and lecturer on atmospheric measurements that led to many programs with China.

1985: Elected Fellow of CIRES, University of Colorado

1995: Selected, Marquis Who's Who in the World

2002: NOAA Administrator's Award for revitalizing Mauna Loa Observatory facilities and operations.

2007: Member of the IPCC that was awarded the 2007 Nobel Peace Prize along with Al Gore.

2008: United States Department of Commerce Silver Medal.

2010: NOAA Distinguished Career Award.

2010: COP 16, Cancun, Mexico – Invited Speaker

2011: NOAA OAR Outstanding Science Communicator Award (1 awarded per year).

2014: Colorado Governor’s Award for High-Impact Research -Atmospheric Impacts of Rapidly Expanding Oil & Gas Development across the West.

2015: Honorary Doctor of Science, University of Alberta, Canada

2019-date; Honorary President. Association for Life-wide Living (ALL) of Alberta

1980-Present: Invited speaker and lecturer by various governments and agencies in numerous countries including Russia, China, India, Azerbaijan, Nepal, Mexico, Ecuador, Iceland, Norway, Denmark, Germany, France, Taiwan, South Africa, Kenya, Switzerland, United Kingdom, Japan, Mongolia, Canada, Korea, Iran, Italy and Austria.

**CONSULTANCIES or Large Project Proposal Award Panels:**

1978-1981: United Nations, World Meteorological Organization, Geneva.

1978-1979: Shell Development Company, Modesto, California.

1981: Universal High Technologies, Yonkers, New York.

1982-1983: University Patents Incorporated, Norwalk, Connecticut.

1983-1984: Frost Technology Corporation, Norwalk, Connecticut.

1988: Eastman Kodak, Rochester, New York

1989: Global Marine Drilling Co., Houston

1990-1991: Holm, Roberts and Owens, Law Practice, Denver, CO

1991: Review Panel, Battelle Northwest Labs, Richland, WA

2012: Review Panel, Swedish Research Council, Stockholm, Sweden

2013- 2016: Funding Review Panel, National Research Council of Canada, Toronto, Canada

2016-date: Member, Alberta Environment and Parks, Science Advisory Panel

2019- date: Collaboratory to Advance Methane Science, Scientific Advisory Board, Houston, TX

2020-date: Consultant, Scientific Aviation, Boulder, CO.

2020-date, Advisory Panel, Colorado-Norway Clean Energy Transition Research and Education Collaboration. Voting member.

### **INTERNATIONAL MEETINGS ORGANIZED:**

First International Biological Ice Nucleus Conference, Laramie, WY, May 1975 (9th held in 2010); Session on Biological Ice Nuclei, AGU Fall Meeting, San Francisco, CA, 1975; AGU Fall Meeting, Session on AGASP/DGASP, 1990; Co-convener, Symposium on the Tropospheric Chemistry of the Antarctic Region, Boulder, CO, 1991; Mauna Loa 40th Anniversary Symposium, AGU, San Francisco, CA 1997; Organizing Committee, Mount Waliguan, 10th Anniversary Symposium, Xining, China, August 2005; Organizing Committee Mount Waliguan, 20th Anniversary Symposium, Xining, China, September 2015; Organizing Committee, 7th International Carbon Dioxide Conference, Boulder, CO, September 2005; Organizer and Chairperson, NOAA Global Monitoring Annual Conferences, 1998 through 2019.

**Major Committees:** National Academy of Sciences, Committee on Aerobiology, 1976-79; Environmental Protection Agency Panel drafting the EPA document "The Potential Atmospheric Impact of Chemicals Released to the Environment, 1979; NOAA Aircraft Instrumentation Upgrade Committee, 1987-89; Convener, IGAC Coordinating Committee, Polar Atmospheric Chemistry, 1990-92; NOAA Polar Committee, 2001 to date; NOAA Pacific Regional Board, 2007 to date.; NOAA Polar Board, 1999-date and numerous NOAA level committees.

### **PATENTS:**

Reducing the Effect, in Plants, of Ice-Promoting Nuclei Originating from Certain Bacteria - U.S. Patent No. 4,311,517. Protecting of Plants Against Frost Injury Using Ice Nucleation-Inhibiting Species -- Specific Bacteriophages - U.S. Patent No. 4,375,734, Canadian Patent No. 1,270,255.

### **PROFESSIONAL SOCIETIES:**

American Meteorological Society, American Geophysical Union, Sigma Tau, American Association for Aerosol Research

### **OTHER INTERESTS:**

Travel (92 countries to date), income real estate investing, public speaking, woodworking.

### **POSTDOCTORAL STUDENTS:**

Name, Year, Publications, Proceedings, **Books**

Wolfgang Ratz	1983-84	12	12	
Howard Bridgman	1986-87	7	5	2
Pat Sheridan	1987-1989	10	9	

Jon Kahl 1987-1989	10	9
Bill Sturges 1989-1991	7	4 1
Irina Sokolik 1991-1992	6	6

## MAJOR FIELD PROGRAMS:

Among the more noteworthy field projects are the Alberta Hail Studies (1964-69); National Hail Research Experiment, Colorado (1973); METROMEX, St. Louis, Missouri (1971-72); Global Ice Nuclei, Europe, USSR, Japan, Burma, Thailand, India and Iran (1971-72); Elk Mountain Observatory Studies, Wyoming (1969-73); Director, Sahel Ice Nuclei Studies, Niger, Dahomey, and Kenya (1974); Project DUSTORM (1975), Texas; USS Hayes Fog Cruise, Grand Banks, (1975); Four Corners Power plant Plume Studies, New Mexico (1975-76); Director, Mount Kenya Baseline Station Project, Kenya (1976-78); WMO Project PEP, Spain, 1979; Johnstown and Homer City Power plant Plume Studies, Pennsylvania (1980); HAMEC, Hawaii (1980); Director, Arctic Gas and Aerosol Sampling Project, Arctic Basin, Greenland, Norway and USSR (AGASP - I, 1983); Director, WP-3D Component of WATOX, Western Atlantic (1986); Director, AGASP - II, Western Arctic (1986); PRECP VI, Illinois (1988); Director, Mt. Kenya Ice Nuclei, Kenya (1988); MISERS GOLD nuclear blast simulation, New Mexico (1989); Army Lidar Validation Program, White Sands Missile Range, NM (1989-90); Director, AGASP - III, Eastern Arctic, and Norway (1989); Director, NOAA WP-3D Component, SJVAQS, Northern California (1990), Kuwait Oil Fire Study (NCAR Electra,) Persian Gulf (May 1991); AGASP-IV/LEADEX, Alaska (April, 1992); Bennett Island Project, Siberia, Russia (March-April, 1992); Russian Arctic Research Aircraft Study, Cherskii, Siberia, April 1993; Mongolia Airborne Carbon Cycle Profile program, 2004-2008; Uintah Basin Winter Ozone Study, Winter 2012 and 2013; Front Range Air Pollution Study, Colorado, 2014; TOPDOWN Gas and Oil Field Emissions Study, New Mexico, 2014; US Mid-Continent Methane Measurement Reconciliation Study, Arkansas, 2015; Alberta Oil Sands Effluent Study, 2018-2020.

**Papers:** Schnell has ~ 200 publications, 9 of which are in *Nature* in four different scientific fields. The first papers in the open literature on biogenic ice nuclei were by Schnell and Vali in 1972 and 1973.

**Below are publications for the past 5 years followed by papers arranged in five different scientific fields that have been cited 10 times or more.**

### 2021

Oltmans, Samuel J., Lucy C. Cheadle, Detlev Helmig, Hélène Angot, Gabrielle Pétron, Stephen A. Montzka, Edward J. Dlugokencky, Benjamin Miller, Bradley Hall, **Russell C. Schnell**, Jonathan Kofler, Sonja Wolter, Molly Crotwell, Carolina Siso, Pieter Tans and Arlyn Andrews, (2021), [Atmospheric oil and natural gas hydrocarbon trends in the Northern Colorado Front Range are notably smaller than inventory emissions reductions](#), *Elementa: Science of the Anthropocene*, 9, 1, 10.1525/elementa.2020.00136

**Schnell, Russell** (2021), *The Great Flood, Arts that flow as Stories from our Landscape: Alberta*, Jane Ross, Ed., Battle River Books, ISBN:978-0-9695841-8-6, p. 37.

Kaushik A., Attri S.D., Kaushik C.P., **Schnell R.** (2021) Climate Resilience and Environmental Sustainability Approaches: An Introduction. In: Kaushik A., Kaushik C.P., Attri S.D. (eds) Climate Resilience and Environmental Sustainability Approaches. Springer, Singapore.  
[https://doi.org/10.1007/978-981-16-0902-2\\_1](https://doi.org/10.1007/978-981-16-0902-2_1)

## 2020

Pétron, Gabrielle, Benjamin Miller, Bruce Vaughn, Eryka Thorley, Jonathan Kofler, Ingrid Mielke-Maday, Owen Sherwood, Edward Dlugokencky, Bradley Hall, Stefan Schwietzke, Steven Conley, Jeff Peischl, **Patricia Lang**, Eric Moglia, Molly Crotwell, Andrew Crotwell, Colm Sweeney, Tim Newberger, Sonja Wolter, Duane Kitzis, Laura Bianco, Clark King, Timothy Coleman, Allen White, Michael Rhodes, Pieter Tans and **Russell Schnell**, (2020), [Investigating large methane enhancements in the U.S. San Juan Basin](#), *Elementa: Science of the Anthropocene*, 8, 1, 10.1525/elementa.038

## 2019

Yalda Vasebi, Marco E. Mehan Llontop<sup>1</sup>, Regina Hanlon<sup>1</sup>, David G. Schmale III, **Russell Schnell**, Boris A. Vinatzer (2019), Comprehensive characterization of an Aspen (*Populus tremuloides*) leaf litter sample that maintained ice nucleation activity for 48 years. *Biogeosciences* 16, 8, 1675-1683, 10.5194/bg-16-1675-2019

Mielke-Maday, I., Schwietzke, S., Thorley, E., Yacovitch, T., Herndon, S.,M., Conley, S., Kofler, J., Handley, P., Miller, B., Hall, B., Dlugokencky, E., Lang, P., Wolter, S., Moglia., E., Crotwell, M., Crotwell, A., Kitzis, D., Vaughn, T., Bell, C., Zimmerle, D., **Schnell, R.C.**, Petron, G. (2018), Methane Source Attribution in a U.S. Dry Gas Basin Using Spatial Patterns of Ground and Airborne Ethane and Methane Measurements, *Elem Sci Anth*, 7, 1, 13, 10.1525/elementa.351

Oltmans, S., Cheadle, L C., Johnson, B. J., **Schnell, R.C.**, Helmig, D., Thompson, A.M., Cullis, P., Hall, E., Jordan, A., Sterling, C., McClure-Begley, A.M., Sullivan, J.T., McGee T.P., Wolfe, D. (2019), Boundary Layer Ozone in the Northern Colorado Front Range in July-August 2014 during FRAPPE and DISCOVER-AQ from Vertical Profile Measurements, *Elem Sci Anth*, 7: 6. DOI: <https://doi.org/10.1525/elementa.345>.

Šantl-Temkiv, Tina, Branko Sikoparija, Teruya Maki, Federico Carotenuto, Pierre Amato, Maosheng Yao, Cindy E. Morris, **Russ Schnell**, Ruprecht Jaenicke, Christopher Pöhlker, Paul J. DeMott, Thomas C. J. Hill and J. Alex Huffman, (2019), [Bioaerosol field measurements: Challenges and perspectives in outdoor studies](#), *Aerosol Science and Technology*, 1-27, 10.1080/02786826.2019.1676395

## 2018

Vaughn, T.L., Bell, C. S., Pickering, C. K., Schwietzke, S., Heath, G.A., Pétron, G., . Zimmerle, D.J., **Schnell, R.C.**, and Nummedal, D., (2018), Temporal variability largely explains top-down/bottom-up difference in methane emission estimates from a natural gas production region. *Proceeding National Academy of Sciences*, November 13, 2018 115 (46) 11712-11717.

Schwietzke, S., Harrison, M., Lauderdale, T., Branson, K., Conley, S., George, F. C., Jordan, D., Jersey, G., Zhang, C., Mairs, H., Pétron G., & **Schnell, R.C.** (2018), Aerially guided leak detection and repair: A pilot field study for evaluating the potential of methane emission detection and cost-effectiveness, *JAWMA*, doi:10.1080/10962247.2018.1515123.

Creamean, J. M., Kirpes, R. M., Pratt, K. A., Spada, N. J., Maahn, M., de Boer, G., **Schnell, R. C.**, and China, S. (2018), Marine and terrestrial influences on ice nucleating particles during continuous springtime measurements in an Arctic oilfield location, *Atmos. Chem. Phys. Discussions*, doi.org/10.5194/acp-2018-545.

Creamean, Jessie M., Katherine M. Primm, Margaret A. Tolbert, Emrys G. Hall, Jim Wendell, Allen Jordan, Patrick J. Sheridan, Jediah Smith and **Russell C. Schnell**, (2018), HOVERCAT: A novel aerial system for evaluation of aerosol-cloud interactions, *Atmospheric Measurement Techniques Discussions*, 1-28, 10.5194/amt-2018-47.

Bian, Lingen, Lei Ye, Minghu Ding, Zhiqiu Gao, Xiangdong Zheng and **Russell C. Schnell**, (2018), Surface Ozone Monitoring and Background Concentration at Zhongshan Station, Antarctica, *Atmospheric and Climate Sciences*, 08, 01, 1-14, 10.4236/acs.2018.81001 .

## 2017

Smith, Mackenzie L., Alexander Gvakharia, Eric A. Kort, Colm Sweeney, Stephen A. Conley, Ian Faloon, Tim Newberger, **Russell Schnell**, Stefan Schwietzke and Sonja Wolter, (2017), Airborne Quantification of Methane Emissions over the Four Corners Region, *Environmental Science & Technology*, 51, 10, 5832-5837, 10.1021/acs.est.6b06107

Schwietzke, Stefan, Gabrielle Pétron, Stephen Conley, Cody Pickering, Ingrid Mielke-Maday, Edward J. Dlugokencky, Pieter P. Tans, Tim Vaughn, Clay Bell, Daniel Zimmerle, Sonja Wolter, Clark W. King, Allen B. White, Timothy Coleman, Laura Bianco and **Russell C. Schnell**, (2017), Improved Mechanistic Understanding of Natural Gas Methane Emissions from Spatially Resolved Aircraft Measurements, *Environmental Science & Technology*, 51, 12, 7286-7294, 10.1021/acs.est.7b01810 .

Huang, Guanyu, Xiong Liu, Kelly Chance, Kai Yang, Pawan K. Bhartia, Zhaonan Cai, Marc Allaart, Gérard Ancellet, Bertrand Calpini, Gerrie J. R. Coetzee, Emilio Cuevas-Agulló, Manuel Cupeiro, Hugo De Backer, Manvendra K. Dubey, Henry E. Fuelberg, Masatomo Fujiwara, Sophie Godin-Beekmann, Tristan J. Hall, Bryan Johnson, Everette Joseph, Rigel Kivi, Bogumil Kois, Ninong Komala, Gert König-Langlo, Giovanni Laneve, Thierry Leblanc, Marion Marchand, Kenneth R. Minschwaner, Gary Morris, Michael J. Newchurch, Shin-Ya Ogino, Nozomu Ohkawara, Ankie J. M. Piters, Françoise Posny, Richard Querel, Rinus Scheele, Frank J. Schmidlin, **Russell C. Schnell**, Otto Schrems, Henry Selkirk, Masato Shiotani, Pavla Skrivánková, René Stübi, Ghassan Taha, David W. Tarasick, Anne M. Thompson, Valérie Thouret, Matthew B. Tully, Roeland Van Malderen, Holger Vömel, Peter von der Gathen, Jacquelyn C. Witte and Margarita Yela, (2017), Validation of 10-year SAO OMI Ozone Profile (PROFOZ) product using ozonesonde observations, *Atmospheric Measurement Techniques*, 10, 7, 2455-2475, 10.5194/amt-10-2455-2017.



Cullis, Patrick, Chance Sterling, Emrys Hall, Allen Jordan, Bryan Johnson and **Russell Schnell**, (2017), Pop Goes the Balloon!: What Happens when a Weather Balloon Reaches 30,000 m asl?, *Bulletin of the American Meteorological Society*, 98, 2, 216-217, 10.1175/BAMS-D-16-0094.1.

Conley, Stephen, Ian Faloon, Shobhit Mehrotra, Maxime Suard, Donald H. Lenschow, Colm Sweeney, Scott Herndon, Stefan Schwietzke, Gabrielle Pétron, Justin Pifer, Eric A. Kort and **Russell Schnell**, (2017), Application of Gauss's theorem to quantify localized surface emissions from airborne measurements of wind and trace gases, *Atmospheric Measurement Techniques*, 10, 9, 3345-3358, 10.5194/amt-10-3345-2017.

Cheadle, L. C., S. J. Oltmans, G. Petron, **R. C. Schnell**, E. J. Mattson, S. C. Herndon, A. M. Thompson, D. R. Blake and A. McClure-Begley, (2017), Surface ozone in the Colorado northern Front Range and the influence of oil and gas development during FRAPPE/DISCOVER-AQ in summer 2014, *Elem Sci Anth*, 5, 61, 10.1525/elementa.254

## 2016.

**Schnell, Russell C.**, Bryan J. Johnson, Samuel J. Oltmans, Patrick Cullis, Chance Sterling, Emrys Hall, Allen Jordan, Detlev Helmig, Gabrielle Petron, Ravan Ahmadov, James Wendell, Robert Albee, Patrick Boylan, Chelsea R. Thompson, Jason Evans, Jacques Hueber, Abigale J. Curtis and Jeong-Hoo Park, (2016), Quantifying wintertime boundary layer ozone production from frequent profile measurements in the Uinta Basin, UT, oil and gas region, *Journal of Geophysical Research: Atmospheres*, 10.1002/2016JD025130.

Oltmans, S. J., A. Karion, **R. C. Schnell**, G. Pétron, D. Helmig, S. A. Montzka, S. Wolter, D. Neff, B. R. Miller, J. Hueber, S. Conley, B. J. Johnson and C. Sweeney, (2016), O<sub>3</sub>, CH<sub>4</sub>, CO<sub>2</sub>, CO, NO<sub>2</sub> and NMHC aircraft measurements in the Uinta Basin oil and gas region under low and high ozone conditions in winter 2012 and 2013, *Elementa: Science of the Anthropocene*, 4, 000132, 10.12952/journal.elementa.000132.

Bian, Lingen, Zhiqiu Gao, Yulong Sun, Minghu Ding, Jie Tang and **Russell C. Schnell**, (2016), CH<sub>4</sub> Monitoring and Background Concentration at Zhongshan Station, Antarctica, *Atmospheric and Climate Sciences*, 06, 01, 135-144, 10.4236/acs.2016.61012

Schnell, Russell (2016), The Power of Ideas, *Beauty Everyday, Stories from Life as it Happens*, Jane Ross Ed., pp 96-118, Friesens Book Division, Manitoba, ISBN: 978-0-9695841-2-4 (hardcover)

## PRIOR PUBLICATIONS:

### Arranged by Field/Themes along with Citations.

Papers with less than 10 Science Citations are not categorized and are listed after the **Climate Forcing, Climate and Related Topics** theme category..

Citations are from Google Scholar in summer 2018.

**1. Biogenic Ice Nuclei.** Russ Schnell discovered three very different classes of biogenic ice nuclei, one produced by a few species of live bacteria on land, a second from decayed plant litter and a third produced by marine phytoplankton. Schnell's first 2 papers on biogenic ice nuclei, as a M.Sc. student, were both in *Nature*. These discoveries established a new field that continues to grow rapidly. Mendeley/Elsevier list 2583 refereed papers that mention studies on biogenic ice nuclei.

Biological ice nuclei have been shown to be the best (active at  $-1.5^{\circ}\text{C}$ ) and the most widespread atmospheric nuclei that initiate the ice phase (i.e. precipitation) in clouds. In the absence of active ice nuclei clouds can supercool to temperature colder than  $-25^{\circ}\text{C}$  without precipitating. Active, living biogenic ice nuclei have even been observed in the Antarctic atmosphere as well as around the Arctic Ocean.

The few species of living bacteria that produce the most active natural ice nuclei also initiate frost damage in plants. By controlling the presence of these bacteria some commercial crops can be protected from frost to temperatures down to  $-4^{\circ}\text{C}$ .

A current focus on biogenic ice nuclei is their role in Arctic clouds in an effort to understand why climate and radiation balance models in the Arctic do not agree with observations. This discrepancy may be related to the presence of ice crystals forming in the lower portions of Arctic stratus clouds at low supercooling temperatures. As very active biogenic ice nuclei have been measured in areas of high primary productivity in the Arctic, these biogenic ice nuclei may be a key to the anomalous ice formation.

There are two large scale commercial applications stemming from biogenic ice nuclei: SNOWMAX used in ski hill snowmaking around the world, and a variety of products to prevent frost damage in commercial food crops by turning off the ice gene in ice forming bacteria living on plants.

Biogenic ice nuclei are also used to help preserve human transplant organs during storage by inducing gentle ice formation in the organs at temperatures just below freezing. Papers covering the discovery of stable biogenic ice nuclei in decayed plant litters (leaf derived nuclei, LDN), in some species of living bacteria (bacteria derived nuclei, BDN) and from marine phytoplankton (ocean derived nuclei, ODN) are presented following.

**Schnell, R.C.** and G. Vali, Ice nuclei from decomposing vegetation. *Nature*, 236, 163-164, 1972. Science Citations = 233

*Nature*, News and Views, "Cloud seeding developments," Editorial comments on the above paper. *Nature*, 236, 139-140, 1972.

**Schnell, R.C.** and G. Vali, World-wide source of leaf derived freezing nuclei. *Nature*, 236, 212-213, 1973. Science Citations = 100

**Schnell, R.C.** and G. Vali, Biogenic ice nuclei, Part I: Terrestrial and marine sources. *J. Atmos. Sci.*, 33, 1554-1564, 1976. Science Citations = 242

Vali, G., M. Christensen, R.W. Fresh, E.L. Galyan, L.R. Maki, and **R.C. Schnell**, Biogenic ice nuclei Part II, Bacterial sources. *J. Atmos. Sci.*, 33, 1565-1570, 1976. Science Citations = 219

“Microbial antifreeze: Gene Splicing Takes to the Field”, Science News of the Week, Editorial using some material from the above paper, *Science News*, 120, 132, 1983.

**Schnell, R.C.**, Ice nuclei in seawater, fog water and marine air off the coast of Nova Scotia: Summer, 1975, *J. Atmos. Sci.*, 34, 1299-1305, 1977. Science Citations = 52

**Schnell, R.C.** and S.N. Tan-Schnell, Kenyan Tea Litter: A source of ice nuclei, *Tellus*, 34, 92-95, 1982. Science Citations = 33

**Schnell, R.C.**, Bacteria acting as natural ice nucleants at temperatures approaching -1°C. *Bull. Amer. Met. Soc.*, 57, 11, 1356-1357, 1976. Science Citations = 26

Fall, R.R. and **R.C. Schnell**, Association of an ice-nucleating Pseudomonad with cultures of the marine dinoflagellate, *Heterocapsa niei*, *J. Marine Res.*, 43, 257-265, 1985. Science Citations = 34

**Schnell, R.C.** and G. Vali, Freezing nuclei in marine waters. *Tellus*, 27, 321, 1975. Science Citations = 39

**Schnell, R.C.**, Ice nuclei produced by laboratory cultured marine phytoplankton *Geophysical Research Letters*, 2, 11, 500-502, 1975. Science Citations = 22

Protection of plants against frost injury using ice nucleation-inhibiting species-specific bacteriophages, L.M. Kozloff, R.C. Schnell - US Patent 4,375,734, 1983. Science Citations = 23

**2. Ozone Chemistry and Oil and Gas Field Effluents.** Schnell is an author on 3 pivotal ozone papers in *Nature*: a highly cited paper showing photochemical ozone destruction in the Arctic; the first scientific publication showing decreasing ozone at the surface in Antarctica; and the first paper showing and explaining wintertime, cold temperature, fast photochemical ozone production in a rural natural gas field. (Science Citations 10).

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## **Past Competitive Research Support**

1983-1991 (\$10 M grant from ONR to Schnell, University of Colorado and Dartmouth University for Arctic Research Topics)

### **Additional Grants**

1985-86 (FY 86) \$1,680,800

1986-87 (FY 87) \$597,000

1987-88 (FY 88) \$566,000

1988-89 (FY 89) \$1,243,000

1989-90 (FY 90) \$1,695,000

1990-91 (FY 91) \$895,000

1991-92 (FY 92) \$911,000

1992-Date: In 1992, Schnell joined NOAA as Director of the Mauna Loa Observatory, Hawaii and in 1998 moved to Boulder, Colorado as Director of NOAA Observatory Operations. In 2005 he became Deputy Director, NOAA/ GMD, with an operational budget in the region of \$20 M/year.

### **Other funding of note:**

\$5M to construct a new road to Mauna Loa Observatory, Federal Highways Administration (2000).

Bureau of Land Management: \$300K for San Juan Basin Methane and Ozone Study (2015).

Government of Alberta: \$1.2M to study effluents from the Alberta Oil Sands Production Field. (2016-2019).