PSNA NEWS

Phytochemical Society of North America
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PRESIDENT'S LETTER

A Preview of the 2002 Annual Meeting in Mérida, México

The evolution of research in phytochemistry illustrates the challenges and opportunities facing plant biology in the next decade. Phytochemistry has been traditionally based on natural product research, from structure determination and cataloguing to establishing biosynthetic relationships, biological activity determination and, to some extent, ecological and evolutionary correlations. As contemporary biochemical and molecular techniques have become routine in the plant biologist's toolbox, they have been incorporated in phytochemical research, to the extent that today it is impossible to conceive of cutting-edge research in phytochemistry without a strong biochemical and molecular foundation. Phytochemistry is, in fact, plant biochemistry although some of the classical plant natural product researchers may not entirely agree. Understanding the biochemical, molecular and evolutionary bases of plant biochemical diversity is, in my opinion, one of the most challenging and exciting areas of contemporary plant biology. This wonderful opportunity is, to some extent, reflected on the increasing visibility of plant biochemical research in the more prominent plant biology journals. What is apparent from these recent examples is that, like every other area of plant biology, phytochemistry will become interdependent with the genomics and post-genomics "revolution".

The last two annual meetings of the PSNA reflect the recognition that molecular and genomic approaches will become every day tools in phytochemical research. The 2000 annual meeting in Beltsville, Maryland was held on the theme of "Regulation of Phytochemicals by Molecular Techniques", and the 2001 annual meeting in Oklahoma City focused on the topic of "Phytochemistry in the Genomics and Post-Genomics Eras". While emphasis on molecular and genomics aspects is important, we also believe that for plant biochemical research to continue to be relevant to plant biology in the future, it must become integrated with other disciplines and also global in scope. This is precisely the rationale for the 2002 annual meeting in Mérida, México. We are bringing together an excellent group of both young and senior speakers that will cover the latest information on the biology of four important groups of plant secondary metabolites in a truly integrative fashion. For each of these groups (alkaloids, terpenoids, phenolics, and glucosinolates) we expect that the plenary speakers and symposium speakers will cover the chemistry, biochemistry, enzymology, genomics where information is available, and ecological chemistry or molecular ecology. Phytochemical research is rather unique among plant biology subdisciplines in that it encompasses a dimension that brings together biology, cultural anthropology and other social sciences. Much of what we know about plant chemistry actually dates back to plant-peo-

continued on page 5

IN THIS ISSUE

CONTENTS

2002
PSNA
Annual Meeting

Integrative Phytochemistry: From Ethnobotany to Molecular Ecology

July 20 - 24, 2002

Mérida, México

The Phytochemical Society of North America (PSNA) is a nonprofit scientific organization whose membership is open to anyone with an interest in phytochemistry and the role of plant substances in related fields. Annual membership dues are U.S. $40 for regular members and $20 for student members. Annual meetings featuring symposium topics of current interest and contributed papers by conference participants are held throughout the United States, Canada, and Mexico. PSNA meetings provide participants with exposure to the cutting-edge research of prominent international scientists, but are still small enough to offer informality and intimacy that are conducive to the exchange of ideas. This newsletter is circulated to members to keep them informed of upcoming meetings and developments within the society, and to provide a forum for the exchange of information and ideas. If you would like additional information about the PSNA, or if you have material that you would like included in the newsletter, please contact the PSNA Secretary and Newsletter Editor. Annual dues and changes of address should be sent to the PSNA Treasurer. Also check the PSNA website at www.psna-online.org for regular updates.

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PHYTOCHEMICAL PIONEERS

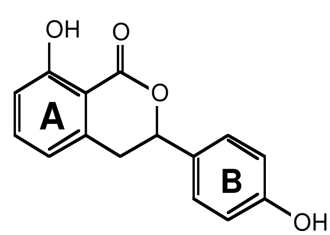
Ragai Ibrahim

A 40-Year Journey in Plant Biochemistry

Looking back over the path of my scientific life of the past 40 years, I recall quite vividly the first turning point in my professional career, after having finished an MSc degree at the University of Alexandria, Egypt, when I came to McGill University more than 40 years ago on a World University Service (WUS) fellowship to study for my PhD degree. It was exactly on Nov 18, 1958 - a Saturday - when I arrived at the Montreal airport and was met by the WUS representative who drove me to the university campus. I walked the corridor of the Botany Department to find an elegant young professor, Neil Towers, caressing a pipe between his lips, while spotting a paper chromatogram on a bench near the entrance of his lab. He quickly determined that I was looking for a supervisor and proposed that I do work on plant phenolics, a novelty at the time. Neil was not disappointed to learn that I had already had a research project to pursue - the biogenesis of the C-N linkage in cyanogenic glycosides. However, I had to abandon that project a few months later, after completing the search for the pertinent methods, when I came across a recent abstract describing the biosynthesis of dhurrin in sorghum by Eric Conn. It was the first, but not the last, time I recognized that name!

I had no regret returning to phenolics and quickly made some original contributions in that new field of research, one of which was the biosynthesis of hydroxybenzoic acids which was published in Nature in 1959 - my first and only paper in this prestigeous journal. This article drew considerable attention from mammalian biochemists, leading to some 300 reprint requests, a hefty number at the time, because it dealt with salicylic, gentisic and *o*-pyrocatechuic acids as plant metabolites, also found in human urine. I isolated and identified the latter acid, for the first time, from the oil of Wintergreen (*Gaultheria procumbens*, Ericaceae), a plant used in folk medicine that we found in the woods of Mount Royal. This work also led to a publication describing the separation and identification by paper chromatography (PC) of plant phenolic acids, which became the hallmark of "Ibrahim and Towers" for a long time. This paper probably encouraged many of the early surveys on phenolic acids by plant scientists, as it drew 185 citations during the time that PC was a popular, and probably the only, separation technique.

The contribution that I was most proud of was resolving the biosynthesis of the phenylisocoumarin, hydrangenol in *Hydrangea macrophylla* roots. It turned out that it incorporates the intact carbon skeleton of a C_6-C_3 precursor into ring B and the 3-carbon side chain, together with three acetate units into the rest of hydrangenol except that, unlike flavonoids, the third acetate unit results in a branched/distorted ring A. This work required the use of various specifically-labeled precursors and high levels of isotope incorporation, since the labeled hydrangenol had to be cleaved to its component rings in order to account for each labeled carbon atom. Resolving this problem would not have been possible without Eric Conn's generous gift of a couple of ^{14}C-labeled compounds that were not commercially available at the time. Following the publication of the preliminary results, I received a letter of encouragement from the late Ted Geissman of UCLA, who was trying to make sure that I could tackle the biogenesis of this molecule. The fact that most of the label of phenylpropanoid precursors was incorporated into the coumarin, umbelliferone and another related compound led to the isolation and identification of a new coumarin derivative, 7-OH-8-OMe-coumarin which we named hydrangetin. This work resulted in three more publications which appeared in 1960-62. In retrospect, it is amazing to realize just how much good science could be achieved with the few primitive techniques available at the time: crystallization, m.p., elemental analysis, UV and IR spectra for structure determination, and the low-sensitivity Geiger-tube for counting radioactivity on paper chromatograms, to the most elaborate technique of combusting labeled compounds to $^{14}CO_2$ and counting the gas in an ion chamber. But these were the 'gold-



Phenylisocoumarin, hydragenol

continued from page 3

rush' days when only a few labs were occupied with the biogenesis of phenolic compounds - Art Neish at NRC, Saskatoon (flavonols), Neil Towers at McGill (dihydrochalcones), and Hans Grisebach in Freiburg, Germany (anthocyanidins), to mention a few.

Working with Neil was a lot of fun, since we had only a few years difference in age, both enjoyed smoking the pipe and having a few beers once in a while. We got along very well, in spite of the rumors and jokes he used to circulate on my successes with women in the lab (as a bachelor at the time). One of these jokes suggested that I was caught holding the hand of a pretty graduate student, and when Neil asked me what I was doing, I said I was just admiring her watch! One of the extracurricular activities in Neil's lab, reserved for experienced students, was to 'biosynthesize' around Christmas time a potent concoction of an alcoholic, herb-spice-orange peel-based liquor, from a recipe claimed to be derived from the Benedictine Monks. That sublime liquid was used to stimulate original scientific ideas and help animate the working environment. However, I did not realize at the time what a privilege it was to work with a guy who later became a Gold Medalist of the Canadian Society of Plant Physiologists, a Fellow of the Royal Society of Canada and, more recently, the winner of the 2000 Pergamon Prize!

I missed the opportunity of doing postdoctoral work in Canada or the U.S., since I had to return to Alexandria at the end of my leave of absence to assume the position of Lecturer in the Faculty of Science, a period that was characterized by the lack of research funds and facilities in addition to a heavy teaching load. However, my return to Canada in 1966 (after experiencing a few adventures!) marked the second turning point in my career when I joined Sir George Williams University in Montreal (later to become Concordia University in 1974 after a merger with Loyola College). With the inception of a Biology MSc program, which I helped to develop, it allowed me to train a few graduate students in a variety of research projects that produced good, publishable results - a period that was marked by a good deal of 'soul-searching' to select a niche that I could develop into a long-term research program. My first sabbatical leave was spent in Hans Grisebach's laboratory in Freiburg, Germany, a beautiful city bordering France and Switzerland, and combining the best gastronomy of the three countries. This stint allowed me to interact with a wonderful group of scientists, including Klaus Hahlbrock, Ulrich Matern, Joe Schröder, Dirk Scheel, Heinrich Sandermann and to meet Jonathan Poulton who was a postdoc with Professor Grisebach at the time. It also gave me the opportunity to purify and characterize, for the first time, the coniferyl alcohol glucosyl-transferase from rose cell cultures and demonstrate its common occurrence in plants.

My appointment in 1980 as an adjunct professor in the Department of Chemistry and Biochemistry at Concordia marked another turning point in my career, as it gave me access to PhD students and allowed me to launch a viable research program. Due to the efforts of a number of dedicated graduate students, who are currently prominent faculty members and senior scientists in the pharmaceutical industry, we were able to make several original contributions to our knowledge of the later reactions in flavonoid biochemistry. Some of these included the discovery of a number of novel, substrate-specific and position-oriented methyltransferases and glucosyltransferases and their ordained sequence in polymethylated flavonol (PMF) glucoside synthesis; resolution of the flavonol 2'- and 5'-*O*-glucosyltransferases using monoclonal antibodies; the localization of PMF glu-cosides by immunofluorescence and immunogold labeling techniques and, more recently, the cloning of genes encoding a number of these enzymes. We also delved into the enormous variety of prenylated isoflavones in lupin roots - having been encouraged by a collaboration with Satoshi Tahara of Hokkaido University - and demonstrated their role as phytoanticipins of germinating lupin, as well as the substrate specificity of lupin root prenyltransferases. This work led to the discovery that lupiwighteone, a mono-prenylated isoflavone together with a C_4 sugar acid, erythronic/tetronic acid, act as molecular signals in Rhizobium-Lupinus symbiosis.

It was Barbara Timmermann of the University of Arizona who drew my attention, during one of the PSNA meetings, to the ubiquity of flavonoid sulfation in plants, that led us to synthesize some 40 different sulfated flavonoids and allowed the characterization of four, position-specific sulfotransferases (STs) in *Flaveria bidentis* (Asteraceae), and determination of the sequence of sulfation in polysulfated compounds. This was followed by the cloning of two (flavonol 3- and 4'-STs) of their genes, and the study of the structure-function relationships that determine their position specificity. Work on sulfotransferases drew much interest from mammalian biochemists and pharmacologists who were interested in phenolic and steroid sulfation as mechanisms involved in xenobiotic detoxification and steroid hormone regulation and, for the first time, plant biochemists were ahead of their animal counterparts.

These were the 'heydays' that marked the peak of my research career and resulted in more than 170 refereed publications, 40 review articles and book chapters, as well as the training of some 30 graduate students and research associates, to whom I am very grateful and proud of their asso-

Ragai Ibrahim

continued from page 4

ciation and continuing relationship. Since my retirement from teaching in 1997, I have focused my research efforts on the methyltransferases, which are hard to remove from under my skin, and their potential use in the metabolic engineering of flavonoid methylation in target plants. This just sums up some of the highlights of my 40-year journey in plant biochemistry, and I hope that my successes have far outweighed my failures - I wish you the same in your career!

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President's Letter

continued from page 1

ple interactions in hunter-gathering societies, early agriculturists and early medicinal traditions. In fact, ethnobotanical research came of age when botany and chemistry merged to become the first generation of bioprospecting work a few decades ago. Unfortunately, with very few exceptions (such as the 1996 annual meeting on "Functionality of Food Phytochemicals" in New Orleans) ethnobotanical contributions have been virtually absent from our meetings. We believe that a plant biochemical meeting that attempts to highlight the continuum from traditional knowledge on plant chemistry through our emerging knowledge of molecular genetics will stimulate much needed dialogue between various levels of inquiry and, hopefully, lead to new collaborations.

We plan on integrating several disciplines in each of the sessions at the 2002 meeting in Mérida. I would like to highlight some of the speakers, topics and unique aspects of this meeting. Eloy Rodriguez, James A. Perkins Professor of Plant Biology at Cornell, has kindly agreed to be our opening keynote speaker for the meeting. Eloy has a distinguished career as a phytochemist and is a very charismatic and engaging speaker. Among his notable recent contributions has been his work on the interface of ecology and phytochemistry suggesting that many species of animals are able to use plants as "medicine". Eloy is also an inspiring role model for minority students and has spearheaded both at Texas and at Cornell, numerous initiatives to encourage students from underrepresented groups to pursue a career in biology. We know very few people who are as committed as Eloy to both innovative research and the development of human resources in the sciences.

Richard Dixon, Director of the Noble Foundation Plant Biology laboratory in Ardmore, Oklahoma will chair the first symposium on phenolics. Rick is the Past-President of the PSNA and has a distinguished record of research on the biochemistry of isoflavonoid biosynthesis. We have asked Rick and all other session chairs to work with the speakers in encouraging talks not only on their individual research programs but also to take the larger view in each of their presentations. This should help the audience appreciate the continuity between the various levels of inquiry. We have also asked the session chairs to provide a brief overview of the session, an introduction to each talk that creates a logical bridge with the preceding/upcoming talk, and to moderate a discussion period that also emphasizes connections and novel approaches. The session on phenolics will be led by Ragai Ibrahim, one of the founding members of the PSNA and one of the world's experts on the enzymology of the flavonoid pathway. A more specific aspect of flavonoid biochemistry which is still under active investigation, namely the origin of acetate moieties for phenolic compounds, will be covered by a Mexican researcher, Mario Rocha from the Biotechnology Institute at the Universidad Autonoma de México. Two young investigators will provide exciting views on molecular evolution and metabolic diversity in the flavonoid pathway. Dr. Joseph Noel of the Salk Institute, a recent CAREER awardee, has developed a method for the efficient expression in bacteria of every key enzyme in the phenylpropanoid pathway, allowing detailed crystallographic and functional studies that were not possible just a few years back. He will share some of his recent findings. Eric Grotewold from Ohio State University has discovered that the overexpression of transcription factors in corn cell cultures leads to major and unexpected diversions of intermediates into various branches of the phenolic pathways. He will discuss the implications of his findings for our understanding of how metabolic diversity is generated. Finally, Heidi Appel will provide an ecological perspective on flavonoid chemistry through her long-term effort to understand interactions between the tannins in oak leaves and gypsy moths.

The terpenoid symposium will be chaired by Edmundo Lozoya from the Centro De Estudios Avanzados at Irapuato. The session will be introduced by Joe Chappell from the University of Kentucky, who will use his many contributions to isoprenoid biochemistry to highlight the generation of diversity as variation on a few basic enzymological themes. One of the recent "tours-de-forces" in chemistry of plant natural products has been the total chemical synthesis, almost 10 years ago, of the diterpene alkaloid paclitaxel (taxol), found in the bark of the yew tree (*Taxus* spp.) and now established as a major anticancer drug.

continued on page 11

FOOD FOR THOUGHT

PSNA Meetings in 2003, 2005, and 2006?

It was agreed in 1998 by the Executive Committee of the PSNA that our annual meetings would alternate between Canada, the U.S.A., and Mexico. Since the majority of the PSNA membership is from the United States, it was also agreed that our annual meetings would be held two consecutive years in the U.S.A. for every year it is held either in Canada or México. Since 1998, successful annual meetings have been held in Pullman, Washington (1998), Montreal, Canada (1999), Beltsville, Maryland (2000), Oklahoma City, Oklahoma (2001) and this year we are looking forward to our get-together in Merida, México. Last year we also agreed to a Canadian offer to host our 2004 annual meeting in Ottawa as a joint gathering of the PSNA and the International Society of Chemical Ecologists (ISCE). However, the membership of the PSNA should be aware we have yet to select a meeting site for 2003. According to our current plan, this meeting should be held in the U.S.A. At this point we run the risk of not holding a meeting next year, unless one of our distinguished colleagues from the United States steps forward and offers to host the event. In fact, we hope the membership will also respond with enthusiastic offers to host PSNA annual meetings in the U.S.A. in both 2005 and 2006! Naturally, we are optimistic that our American colleagues will respond and we fully expect several offers to be submitted to the PSNA Secretary, Peter Facchini (pfacchin@ucalgary.ca). He will compile the list for discussion at our annual business meeting in Mérida. Please give this appeal serious thought since it is imperative that we identify parties capable of organizing the meeting, especially for 2003.

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Is it Time for a Change?

Throughout the history of the PSNA, our society has followed a strict policy of electing a new President whose term lasts just a single year. Several years ago, the issue of extending the term of the Society President from one to two years was raised at an annual business meeting of the PSNA membership. Although this issue was discussed extensively, no conclusive decision was reached. The effect of this inaction has had some consequences, since it has become increasingly more difficult to find suitable candidates who are willing to serve the PSNA in the very important capacity of President. In addition, the short term of the President contributes indirectly to the lack of continuity and knowledge required for the smooth running of the Society. This reality was evident this year when some confusion was encountered concerning the organization of the annual meeting to be held in Mérida, México this summer. Fortunately, the problem has been resolved in a timely manner, and we appear to be on track again for another outstanding annual meeting. However, it must also be noted that we have yet to select a site for our 2003 annual meeting (see the above article entitled "PSNA Meetings in 2003, 2005, and 2006"). It seems that we are beginning to operate too close to the edge. Again, the problem appears to be that, from time to time, no one is really sure who is in charge of the Society. Would extending the term of the President to two years contribute to more timely decision making? Opinions from the membership on this topic would be greatly appreciated. Please send your comments and opinions to the PSNA Secretary, Dr. Peter Facchini (pfacchin@ucalgary.ca). He will post them on the PSNA Web site. This open forum could be followed by a more detailed discussion at the annual business meeting in Mérida.

If sufficient consensus can be reached, the Executive Committee might wish to pass a motion for a vote to extend the mandate of the President of the PSNA to two years. This is an important decision that requires careful consideration by our members.

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SOUTH OF THE BORDER

What's Brewing? Coffee!

Introduction

Would you like a cup of coffee or tea? This is a question that you can hear any place around the world. Coffee and tea are two plants that people use to produce beverages. In fact, coffee is, after oil, the major commodity in the world. Actually, we know that caffeine is the major component in the stimulatory action of these two drinks, and the flavor and aroma are the result of the combination of an important number of compounds. Caffeine is also a strong insecticide, and has been described as a natural herbicide. These plants are fertile soil for biochemists, molecular biologists and phytochemists.

History

The use of coffee as a beverage is surrounded by legends and history. However, classic writings from Egypt and early Greeks and Romans have no mention of coffee. The history of coffee can be traced to northern Africa. The Arabian Doctor Rhazes, made the first written account of coffee around the year 940 A.D,. The earliest coffee was grown in Ethiopia and cultivation spread to Yemen in southern Arabia, where the custom of roasting beans began around 1200 A.D. In the fifteenth century, coffee came to Mecca, center of the Islamic world. Coffee houses developed there and Muslim pilgrims spread news of this wonderful tonic drink to every corner of the Islamic empire, including Spain, Egypt, Iran, and Turkey. Gradually, coffee spread to all of Europe. More information on the history of coffee can be found at the Web site: http://www.warbuckscoffee.com/briefhis.htm.

Folk medicine

Coffee has been known in early medicine in Arabia, Europe, and America, for many and diverse purposes. It has been reported to be an analgesic, aphrodisiac, anorexic, antidotal, cardiotonic, CNS-stimulant, counterirritant, diuretic, hypnotic, lactagogue, nervine, and a stimulant Coffee is also a folk remedy for asthma, atropine-poisoning, fever, flu, headache, jaundice, malaria, migraine, narcosis, nephrosis, opium-poisoning, sores, and vertigo. For more information about the use of coffee in folk medicine visit the following Web site: http://www.hort.purdue.edu/newcrop/duke_energy/Coffee_arabica.html).

Trade

The major producers of coffee are Brazil, Colombia, Indonesia, Vietnam and Mexico, and it is the main source of foreign exchange for several countries. There are two species that constitute most of the coffee trade: *Coffea arabica* and *C. canephora*.

Turkish coffee merchant

Research

The use of low-level stimulants, such as caffeine is part of almost every culture on Earth. In the case of caffeine six plant species are used: coffee (*Coffea arabica* L. y *C. canephora* Pierre ex Froehner), tea (*Camellia sinensis* (L.) O. Kuntze), cacao (*Theobroma cacao* L.), mate (*Ilex paraguariensis* St. Hil.), guaraná (*Paullinia cupana* H.B.K.) and cola (*Cola acuminata* (P. Beauv.) Schott et Endl). Since such beverages are consumed daily, or at least very frequently, its active principle is a regular component of the human diet. For adults the daily intake of this compound is around 3 mg kg^{-1} (1). Caffeine is a purinic alkaloid. These compounds are derived from xantine or uric acid, with a neutral or acidic character. Such alkaloids are widely distributed in the plant kingdom and have been found in at least 90 species (1).

The interest in the study of caffeine biosynthesis has three components: the first is its role as a defense product in those plants that produce it; second is the fact that the caffeine contributes to the quality of the coffee in the cup; the third component comes from the human physiology. Actually there is a controversy around the possible physiological role that caffeine can play in the human body. The possible effects produced by caffeine are: palpitations, gastric disturbs, anxiety, increase in the blood pressure and insomnia. As a consequence there is an increase in the demand for coffee without caffeine.

Recently, the pathway for the caffeine biosynthesis has been determined using different techniques in tea and coffee leaves: AMP $\rightarrow$ IMP $\rightarrow$ xantosine 5'-monophosphate $\rightarrow$ xantosine $\rightarrow$ 7-methylxantosine $\rightarrow$

continued on page 20

THE UNKNOWN PHYTOCHEMIST

Baloney-omics

What is it with all the new terms in the biological sciences these days? I mean, I can understand that new words are coined when something *new* is developed. But, is it really necessary to change the name of techniques and disciplines from descriptive terms that have served us well for decades to more politically appealing words and phrases that pay homage to the emerging dominance of "genomics" in modern biological research? When the whole genomics thing really got rolling a few years back, the word "genomics" seemed exciting, powerful, and a bit mysterious partly because few people really understood what it meant. The novelty of the term conveyed the importance of the revolution about to be hurled upon us. But, we soon started hearing other words, like "proteomics". This term created confusion at first. It sounded very technical. Some of us felt left out because we really didn't understand what proteomics was all about. Many others pretended to understand especially when the rumor got out that proteomics was just a fancy-schmancy way of saying that you knew how to run a 2-D polyacrylamide gel. But, no! Proteomics was much more than that! Hasn't your department invested in a MALDI-TOF mass spectrometer yet? How do you intend to join the proteomics revolution? Okay, so we learned all we could about proteomics and how it was going to change the world. And, yeah, okay, fine, it does represent more than just running 2-D gels. But, just as we were getting comfortable with the infusion of "genomics" and "proteomics" into the modern lexicon, along comes "metabolomics". Or is it "metanomics"? Apparently, one term was no longer enough to represent the vast potential of such mind-boggling technologies. At that point, many

of us started to understand what was happening. The genomics revolution had given rise to "omic-mania". It then became possible to actually predict changes in terminology. No longer would it be acceptable for the "in" crowd to describe their routine HPLC analyses at a PSNA annual meeting. Now, the beautiful people of science were doing "metabolic profiling". "What's the difference" many of us asked sheepishly, barely masking our growing inferiority complex? Oh, there's a BIG difference, we were told. Metabolic profiling and other genomic technologies produce so much more data that you couldn't possibly fit it all into your insignificant, prehistoric brain…you'll need a computer. And so, we witnessed the birth of the bioinformatist, who conducts research *in silico*. Why waste your time with filthy organisms, smelly chemicals, and long hours in the lab when you can use computers to sift through reams of data while you sit by ready to re-boot at the first sign of trouble?

That's when the avalanche really began. Messenger RNA became the transcriptome, proteins became the proteome, metabolites (including our beloved natural products) were relegated to the metabolome, Clearly, the new terminology must be sanitized for our own protection. Having a genome just wasn't enough. Soon we learned of the vacuolome, the chloroplastome, yada, yada, yada. Anyway, my point is, why stop there? I believe that it is our turn, not to mention our right, to jump on the bandwagon. Out with secondary metabolism. In with "phytochemicalomics". And take note, you heard it here first!

Do you have a "strong" opinion about a phytochemical issue that you wish everyone could read, but don't want anyone to know its you? The Unknown Phytochemist column might be just what you've been waiting for. This tongue-in-cheek submission is the first (and perhaps the last) of its kind. All submissions will be carefully edited for good taste. Thank you to the author of this entertaining piece, whose identity shall forever remain anonymous - the Editor.

Dry Bones, Israel

CURRENT OPINION IN CHEMICAL ECOLOGY

Phytochemicals Link Heaven and Earth: Induced Plant Responses Mediating Interactions Between Root and Shoot Herbivores

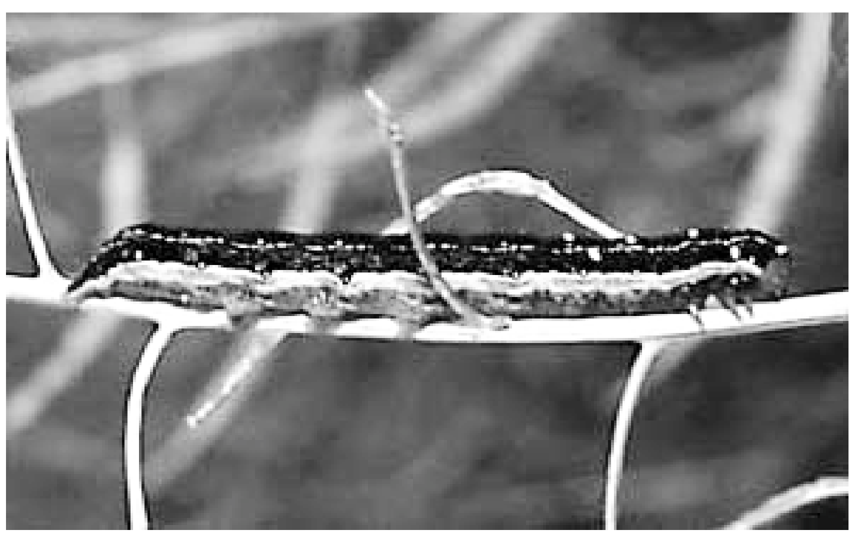
Although mankind may like to think that plants produce phytochemicals mainly for human benefit, one of the primary roles of these so-called secondary metabolites is to defend their producers against attacks of herbivores, pathogens and other phytophages (Fraenkel, 1959; Harborne, 1989). Many plants indeed increase the production of defensive compounds in response to phytophage attack (Karban and Baldwin, 1997; Agrawal et al., 1999). These induced defenses can directly affect phytophage by increasing their mortality or decreasing their growth rates (van Dam et al., 2000; van Dam et al., 2001). Additionally, attacked plants may produce indirect defenses, such as volatile compounds or extra-floral nectar. Indirect defenses attract predators or parasitoids to the damaged plant, which increases the probability that the phytophages are found and consumed by their natural enemies (Dicke and Sabelis, 1988; Wäckers and Wunderlin, 1999). Eventually, the plant may benefit from both direct and indirect induced responses if they decrease loss of biomass and increase net seed production (fitness) compared to plants that do not induce their defenses.

So far, the chemical-ecological aspects of induced responses in plants have been studied almost exclusively on above-ground phytophages and their natural enemies. There is, however, ample evidence that root phytophages, such as nematodes, bacteria, fungi or arthropods, also induce defensive plant responses. Similar to their aboveground counterparts, root-induced responses may also affect root phytophages and their soil-dwelling natural enemies (van Tol et al., 2001; van Dam et al., 2002). Both root and shoot phytophages may elicit systemic responses if the signaling compounds that are produced are transported throughout the entire plant and alter chemical profiles of undamaged organs (Karban and Baldwin, 1997; Agrawal et al., 1999). Thus, by inducing the plant's defensive responses, root feeders may alter host quality for shoot herbivores, and vice versa. Eventually, such interactions may affect the performance of above-ground (AG) and below-ground (BG) phytophages - and their natural enemies - and consequently, the eventual amount of damage the plant will suffer.

Because there are no explicit studies yet on how inducible compounds mediate interactions between AG and BG phytophages, I can only support the idea that they do by combining separate studies on shoot or root induction processes. As an example, I will use the induction of glucosinolates in the Brassicaceae. Glucosinolates are a very diverse class of plant compounds known to deter feeding by generalist insect herbivores, pathogens and nematodes (Fahey et al., 2001). When plant cells are ruptured, the glucosinolates that are stored in the vacuoles are metabolized by the enzyme myrosinase that is stored in specialized storage cells. This enzymatic reaction yields toxic products such as isothio-cyanates and nitriles, that are even more potent feeding deterrents against a wide range of phytophages (Brown and Morra, 1997; Rask et al.,2000). Both myrosinase and glucosinolate levels increase systemically after herbivore feeding, pathogen infection or after application of induction hormones such as jasmonic acid and salicylic acid (Bodnaryk, 1994; Ludwig-Müller et al., 1997).

The different types of glucosinolates are known to differ in induction profiles and biological activities. Here I will focus on the role of 2-phenylethyl glucosinolate (nasturtiin) which is found in the roots and shoots of several economically important *Brassica* species (Kiddle et al., 1994; Ludwig-Müller et al., 1997).

continued on page 10



The Bertha Armyworm causes severe damage to canola and other crops

continued from page 9

Nasturtiin and its breakdown products are known to be nematicidal, fungitoxic and inhibit microbial growth (Potter et al., 1999). Shoot treatment with jasmonic acid - which is widely used to mimic induced responses after insect feeding - also increased root levels of nasturtiin (Ludwig-Müller et al., 1997). This indicates that shoot herbivores may very well alter the suitability of the roots as food for nematodes feeding on the same plant. Whether the reverse is true so far remains unexplored, but studies with nematodes on cultured tobacco have shown that nematode feeding indeed may increase shoot levels of defensive phytochemicals, such as nicotine (Davis and Rich, 1987). If nematodes indeed increase shoot glucosinolate levels, this may even affect aboveground natural enemies of specialist herbivores on Brassica plants that use these compounds for their own defense (Müller et al., 2001). If these specialist herbivores, that are not deterred by the induction of glucosinolates, become more resistantto their own enemies, inducing plants may eventually suffer more damage than non-inducing plants.

The above example, and a few other examples of well-studied biologically active phytochemicals (van Dam et al., 2002) show that there is a significant potential for induced responses to mediate interactions between above- and belowground phytophages and their natural enemies. This awareness will not only change our views on which natural selection pressures have played a role in the evolution of induced chemical defenses in plants, but also will have consequences for the application of induction hormones for 'plant immunization' in agricultural systems. Therefore, it is about time that those studying induced responses 'go underground' to include root-induction processes and their interactions with shoot-induced responses in their studies. This is publication 2948 NIOO-KNAW Centre for Terrestrial Ecology, Heteren, The Netherlands

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A parasitic wasp laying eggs on a canola leaf

President's Letter

continued from page 5

As is the case for many complex phytochemicals, we are still far from an understanding of how taxol is synthesized in Taxus cells. Kevin Walker,a young investigator from Washing State University will discuss recent progress in the enzymology and molecular biology of taxol biosynthesis. We now are beginning to have good examples of how genomics and biochemistry can make a powerful combination in the study of plant secondary pathways. Another young researcher at the University of Michigan, Eran Pichersky, will discuss his exciting work on the synthesis of terpenes and phenolics in the leaf trichomes of species of the mint family, with focus on two novel gene families that appear responsible for a wealth of scents and flavor compounds. The session will be closed by Maria Luisa Villareal from the Biotechnology Institute at Cuernavaca, who will address how biotechnological approaches can help in the preservation of biodiversity from traditional medicinal plants.

Although it is widely accepted that the immense diversity of plant natural products can be mostly explained as variations on a few major themes, we are still far from developing a conceptual framework to explain the evolution of plant secondary metabolites. This is due, at least in part, to the lack of suitable genetic models. This is quickly changing as the result of the completion of the Arabidopsis genome sequence. Although this species is not known for its chemical diversity, as a member of the Cruciferae it expresses a fair number of glucosinolates, a relatively small (by comparison with phenolics, alkaloids and terpenes) family of sulfur-containing secondary metabolites derived from aliphatic or aromatic amino acids. Using genomic information, mutant and ecotype screening and classic biochemical analysis, Jonathan Gershenzon and colleagues at the Max Planck Institute for Chemical Ecology are establishing a sound basis for our understanding of the biological significance of glucosinolates. Jonathan has kindly agreed to lead a short symposium highlighting recent advances in glucosinolate biology, biochemistry and chemical ecology. He will also present a plenary lecture on the function of volatile terpenes.

The emphasis of the Arthur Neish Young Investigator Symposium will focus on promising new faculty members. We have chosen to highlight the work of two young men and two young women. Jorge Vivanco of Colorado State University, a recent CAREER awardee, will talk about his recent efforts to develop a metabolic profiling system applicable to the study of root exudates, one of the least understood aspects of root phytochemistry. Argelia Lorence, a postdoctoral associate at Virginia Tech, will talk about her recent collaboration with Mexican colleagues, which identified a novel group of allelochemicals from the Convolvulaceae with antiherbivory properties. Melina Lopez, a recent faculty member at the IPN in Sinaloa, will discuss her work on novel aspects of medicarpin biosynthesis. Finally, Sergio Peraza from CICY will complete this session by addressing his work on traditional Mayan medicinal plants with promise in the treatment of protozoan parasites.

The final symposium of the meeting on alkaloids will be chaired by Dr. Vince De Luca, a recent President of the PSNA and a newly chaired professor at Brock University in Canada. Vincenzo has made fundamental contributions to our knowledge of the compartmentation of alkaloid biosynthesis, using the *Catharanthus* tryptophan-derived alkaloid complex as a model. Jeffrey Cordell, one of the founding members of PSNA, will lead the session with an overview of the ethnobotany and chemistry of alkaloids as well as a perspective on future research. Peter Facchini, Canadian Research Chair in Plant Biotechnology at the University of Calgary, will provide a cell biological overview of alkaloid biosynthesis. This is a particularly challenging area of research in the case of alkaloids, as it is well known that multiple cell compartments participate in their biosynthesis. Vincenzo De Luca will complement this picture with a molecular view, and the session will be closed by Dieter Ober with a perspective on the ecological *raison d'être* of alkaloids.The outstanding line up for the regular session will be complemented by several keynote and plenary session speakers. In addition to Eloy Rodriguez and Jonathan Gershenzon, Barbara Timmermann will give a summary of a seven-year-old project on Biodiversity Prospecting. This is an excellent example of the challenges involved in academia-industry partnerships in developed and developing countries. Xavier Lozoya, one of the most renowned investigators on Mexican medicinal plants, will discuss how traditional knowledge may be integrated with molecular approaches in a way the benefits all partners and fosters sustainable development of novel products and industries. Mercedes Lopez from CINVESTAV will provide a combined industry and academic perspective on the use of phytochemistry in the development of traditional and modern fermented products. Finally, Robert Bye will close the meeting with an overview of plant-people interactions in Mexico from pre-Columbian to modern times.

This year's annual meeting promises to be informative and stimulating. I encourage you to come to Mérida for both the outstanding science and the opportunity to experience some famous Mexican hospitality.

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ACROSS THE POND

A Canadian Postdoc in Germany

A trip across the Atlantic for a period of postdoctoral work is a common part of the career of many European scientists. North American research groups often have a German or Scandinavian postdoc as part of their multicultural makeup. But the reverse, with scientists making the trip from the New to the Old World to do research, is not so common. When I chose to go to Germany for postdoctoral work after finishing a PhD in 1998 (with Neil Towers at the University of British Columbia), I was swimming against the tide. I had received an NSERC postdoctoral fellowship and used the chance to expand my scientific base, to build on my phytochemical background by studying molecular aspects of plant secondary metabolism, but also to live somewhere different for a few years. I decided to join the research group of Toni Kutchan first at the University of Munich, and since 1999 at the Leibniz Institute of Plant Biochemistry (IPB) in Halle.

My time here has been both scientifically and personally rewarding. Germany has long been a world leader in plant biology and plant biochemistry, and when I look back at the last few years I can see the benefits of being part of this base of knowledge and expertise. My initial plan of a two-year stay has stretched into four and I now have my own research group that uses functional genomics tools to dissect out biosynthetic pathways in *Cannabis sativa* and tobacco. It has also been eye-opening to learn about other ways of doing science and living in a country different from my own.

German speaking countries have a unique scientific culture. Yes, they have a reputation for their rigid Herr Professor Doktor hierarchy (which does exist) but this is mellowing with time and with generational change. When I arrived I wasn't aware of the differences between the university systems in North America and Germany. For example, the "Diplom" is roughly equivalent to a master's degree, involving course work and exams followed in the natural sciences by a six to eight month period of lab work. I say roughly because the Diplom doesn't approach the level of practical experience gained during the two to three year MSc degrees that my Canadian colleagues did. A German PhD takes about three years, with no course work, and PhD students start to get

Guesthouse of the Leibniz Institute

impatient when they are in the lab much longer than that. Of course with thesis writing and waiting for examining committees the whole process is more like 3.5 years but this is still somewhat shorter than for a PhD in Canada or the US. After a PhD, German researchers aiming for an academic career in science will often go abroad for a year or two, and then return as a group leader and/or a "Habilitant". The Habilitation is a major difference between academia in North America and Germany, and can be thought of something approximating an assistant professorship. It involves a period of five or more years, under the guiding eye of a senior professor, where one develops as an independent researcher. It requires the writing of a Habilitationschrift (a sort of second thesis) and a defense before an examining committee. The Habilitation also ends with having to find a new job - academics rarely, if ever, obtain a permanent faculty position at the university where they habilitated. The Habilitation is being hotly debated at present as some would replace it with an assistant professor position while others support it as a valuable and still important part of the German scientific system.

Halle, where I moved after a year and a half in Munich, is a city of 250,000 inhabitants located about two hours south of Berlin in the former East Germany. It's a fascinating and dynamic time to be in one of the "Neue Länder" (New States) which were part of the Eastern Bloc for more than 40 years. A massive amount of construction is being undertaken to bring the former East up to the level of the West. In East Germany, the old cities had fallen into disrepair as citizens moved into high rise worker housing in the suburbs. Now the crumbling 19th Century and older architecture in cities like Halle is being restored and renovated. Baustellen (construction sites) are ubiquitous, which may make driving and walking the streets here somewhat hazardous, but they also mean that your neighbourhood is constantly changing, with stores and cafés springing up overnight in previously derelict buildings. Situated in a former industrial heartland, high unemployment and a long closed society have meant that Ausländerfeindlichkeit (anti-foreigner feeling) is sadly high in cities like Halle. This doesn't translate into problems for a Canadian scientist but it is a cause

continued on page 21

PHYTOCHEMICAL SOCIETY OF NORTH AMERICA
2002 ANNUAL MEETING

July 20-24, 2002
To be held at Hotel *El Conquistador*
Paseo de Montejo No. 458, Mérida, Yucatán,México

"Integrative Phytochemistry: From Ethnobotany to Molecular Ecology"

Tentative Program

Saturday, July 20: 4:00 - 6:00 pm - Registration

6:00 - 9:00 pm: Welcoming Reception and Dinner
Keynote Address: Eloy Rodriguez (Cornell University)
"Plants, People and Ethnomedicine: From Chimps to *Homo sapiens*"

Sunday, July 21: 8:30 am – 1:00 pm - Symposium I: Phenolics (Chair: Richard Dixon)

Ragai Ibrahim, Concordia University, Montreal, Canada
"The Enzymatic Basis of Flavonoid Biodiversity"
Mario Rocha, IBT, UNAM, México
"Provision of Acetate Units for Flavonoid Biosynthesis
Joseph Noel, Salk Institute
"Structural, Functional, and Evolutionary Basis for Methylation of Plant Natural Products"
Erich Grotewold, Ohio State University
"Transcription Factors and Metabolic Diversity"
Heide Appel, Penn State University
"Flavonoids and Plant-Insect Interactions"
Plenary Talk: Barbara Timmermann, University of Arizona
"Drug Discovery from Biological Diversity – The International Cooperative Biodiversity Groups Program in Latin America"

3:00 – 5:00 pm: Poster Session

Monday, July 22: 8:30 am – 1:00 pm - Symposium II: Terpenes (Chair: Edmundo Lozoya)

Joe Chappell, University of Kentucky
"The Chemical Wizardry of Isoprenoid Metabolism in Plants"
Kevin Walker, Washington State University
"Taxol Biosynthesis: Stepping Along its Way"
Eran Pichersky, University of Michigan
"Two Novel Gene Families are Responsible for the Synthesis of Numerous Plant Scents and Flavors"
Maria Luisa Villareal, Universidad Autonoma del Estado de Morelos, Mexico
"Production of novel bioactive steroidal saponins and triterpenes in cell and tissue cultures of native Mexican medicinal plants"
Nikolaus Fischer, University of Mississippi
"Constituents of North American Magnolias: Structure, Chemistry,
Biogenesis and Biological Activities"

Symposium II: Terpenes - continued

Plenary Talk: Xavier Lozoya, Instituto Mexicano del Seguro Social
"Integrating Cultural Tradition and High-Tech R&D in the Development of Novel Phytoproducts"

3:00 – 7:00 pm - Symposium III: Glucosinolates (Chair: Jonathan Gershenzon)

Jed Fahey, Johns Hopkins University
"Biological Activity of Glucosinolates"
Erik Andreasson, University of Copenhagen, Denmark
"Compartmentation of Glucosinolate Synthesis and Catabolism"
John Rossiter, University of London, England
"Novel Myrosinase in Aphids feeding on Glucosinolate-containing Plants"
Dan Kliebenstein, University of California
"Molecular and Genomic analysis of Glucosinolate Pathway Evolution
Ute Wittstock, Max-Planck Institute for Chemical Ecology, Germany
"Glucosinolate Hydrolysis in Plants and Insects: Implications for Plant-Herbivore Interactions"
Plenary Talk: Jonathan Gershenzon, Max Planck Institute for Chemical Ecology, Germany
"Puzzling perfumes- investigating the formation and function of volatile terpenes released from plant foliage"

Tuesday, July 23: 8:30 am – 1:00 pm - Arthur Neish Young Investigator Symposium

Jorge Vivanco, Colorado State University
"Metabolic Profiling and Functional Characterization of Root Exudates: The Secondary Metabolite Story"
Argelia Lorence, Universidad Autonoma de Morelos, México
"Holes in the Membranes: How allelochemicals in the morning glory family dispose of enemies"
Sergio Peraza, Centro de Investigacion Cientifica de Yucatan, Méxcio
"Bioassay-Directed Studies of Yucatecan Medicinal Plants with Antiprotozoal Activity"
Melina Lopez, Instituto Politecnico Nacional, CIDIR, México
"Novel Aspects of Medicarpin Biosynthesis"
Plenary Talk: Mercedes Lopez, CINVESTAV, Irapuato, México
"Chemistry of Flavor, Aroma and Volatiles in Traditional Fermented Plant Products"

3:00 – 5:00 pm: Tour of the Botanical Garden at CICY

6:00 – 9:00 pm: Dinner and Awards Ceremony
Closing Address: Robert Bye, Director of the Botanical Garden., Universidad Nacional Autonoma de México
"On Plants, People, and Phytochemicals"

Wednesday, July 24: 8:30 am – 12:00 pm - Symposium IV: Alkaloids (Chair: Vincenzo De Luca)

Jeffrey Cordell, University of Chicago
"A Perspective on Alkaloids: Past, Present, and Future"
Peter Facchini, University of Calgary, Canada
"Cell Biology of Alkaloid Biosynthesis"
Vince DeLuca, Brock University, Canada
"Molecular Biology of Plant Alkaloids"
Dietrich Ober, Technical University Braunschweig, Germany
"Chemical Ecology of Plant Alkaloids"

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“Integrative Phytochemistry: From Ethnobotany to Molecular Ecology”

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NORTHERN EXPOSURE

Of Mines and Men

It could be argued that the expanding use of herbal remedies in North America has now contributed to the first steps in the legalization of a traditionally problematic narcotic plant. Although no one has ever been busted for trafficking *Echinacea* or St. John's Wort, the marijuana plant continues to be a major source of social and economic concern. Marijuana is a species with both strong proponents and bitter detractors. Now, in addition to its role as a world-renowned exporter of canola, controversial figure skaters, and cold fronts, Canada has made a mark on the marijuana debate. On April 7, 2001 the Canadian government proposed new regulations for the legalization of marijuana and other substances for certain medicinal purposes. The legislation affects drugs containing cannabinoids (such as marijuana, hashish, and hash oil) and psillocybin (the active ingredient in magic mushrooms). Despite its questionable virtues, marijuana is no doubt a phytochemically and biochemically interesting plant, boasts an impressive cultural "heritage", has widespread socio-economic implications, and is now providing law-abiding Canadians with something to think about between Olympic gold-medal victories in ice hockey over their neighbours to the south (sorry, couldn't resist).

Let's start with some interesting trivia that is unlikely to become an official Trivial Pursuit category. *Cannabis sativa* is cultivated or grows wild in most countries in tropical or temperate zones, including Canada. The plant, which probably originated in Asia, has been cultivated for a long time. Street language has given marijuana several different names, including pot, grass, and weed in English-speaking countries. In India, medium quality marijuana is called bang and high quality marijuana is known as ganga. It is also called ganga in Jamaica, kif in Morocco, and dagga in South Africa. *C. sativa* also produces an amber-coloured resin which, in an almost pure form, is a drug called charas in India and hashish in Western and Middle-Eastern countries. As for the word marijuana, its etymology is not clear. Some sources suggest that it is the contraction of two first names that are popular in Mexico, Maria and Juana. Others think that the term comes from the Mexican word mariguano, which means intoxicant, or the Panamanian word managuango, which means the same thing. The plant has many uses. It provides strong textile fibres used for the manufacture of wires and cables. The fibres can also be used to make blankets, clothes, flags, and boat sails. The seeds contain oil, of similar quality to linseed oil, used to manufacture soap and paint.

The first description of *C. sativa* comes from a medical treatise attributed to the Chinese emperor Chen-Nong from around 2,700 B.C. Archeological discoveries in Egypt dated between 3,000 and 4,000 years old also reveal the ancient exploitation of this plant. The Greek historian Herfodotus mentions that inhaling smoke from *C. sativa* was a funeral purification rite of the Scythians, who were a people that spoke Iranian and lived between the Danube and the Don rivers beginning in the 12th century B.C. The oldest of the Veda, which are sacred Hindu books written in Sanskrit after 1,800 B.C. describes the properties of *C. sativa*. Similarly, the Avesta, which is the holy book of the Zoroastrians, who originated in Northern Persia, dates from 600 B.C. and mentions that the resin of *C. sativa* produces drunkenness. In Europe, marijuana use did not develop socially or medicinally until the return of Napoleon's expeditionary forces from Egypt in 1798. Western medicine began to take a much greater interest in *C. sativa* due

There really is a place called Flin Flon (centre of the map).

to the work of two authors: O'Shaughnessy, an English doctor who returned from India in 1843 and Moreau de Tours, a Frenchman who wrote about the medicinal use and abuse of marijuana in 1848. The use of *C. sativa* in Europe only began to gather a significant following in 1844 when the Club des Hachichins was founded in Paris. Its members included Balzac, Hugo, Baudelaire, and Gautier. The first Canadian colonist to grow marijuana was apparently the French apothecary Louis Hébert who travelled to Québec in 1606 with the explorer Samuel de Champlain.

The popular use of marijuana gained considerable notoriety during the 1960s. More recently, some health care professionals have publicly endorsed its use for therapeutic benefits associated with four serious disorders. First, by lowering eye pressure it is purported to control glaucoma. Second, it is believed to reduce spasms in victims of multiple sclerosis. Third, it has been suggested to reduce nausea and suffering in patients undergoing chemotherapy and other cancer treatments. And finally, it is widely claimed to help those with AIDS to fight depression and regain the appetite they need to survive. It is also felt by some that marijuana can help those suffering from certain diseases, such as migraines and emphysema. The role of tetrahydrocannabinol (THC) as the active narcotic compound in marijuana has long been recognized. There are currently drugs sold legally in several countries that contain THC. In Canada, the two approved drugs sold in pill form that contain active ingredients derived from marijuana are Marinol and Cesamet. Presumably, these medications, which have passed the strict drug submission procedure and received a notice of compliance and an identification number, offer patients suffering from the aforementioned disorders with legal solutions to THC-associated therapy.

Proponents for the legalization of medicinal marijuana argue that prescription medicines containing THC are expensive, unpalatable, and often ineffective for many patients. However, *smoking* marijuana (so the argument goes) provides immediate relief of nausea, a loss of appetite, and other symptoms associated with the disease such as cancer and AIDS. Moreover, the holistic attitudes of herbal remedy advocates would contend that THC is but one of many compounds found in inhaled marijuana smoke, and that it is this chemical cocktail that is essential for the palliative treatment of certain conditions. Of course, people who currently chose to ignore laws about the use of illicit plant materials, even for therapeutic purposes, were at risk of arrest, fines, court costs, property forfeiture, incarceration, probation, and criminal records.

The Canadian answer to this dilemma has been to create a medicinal marijuana policy, which came into effect on July 30, 2001 and allows people who have been granted an exemption from narcotics laws to possess pot and grow it, or have someone else grow it for them. So far, only a few hundred people have been approved with several thousand applications pending. Allan Rock, the former Minister of Health in Canada, says that the use of marijuana to help people suffering chronic pain is based on logic and common sense. "Its a matter of simple compassion and reflects the views of Canadians in general", Rock said. Although Rock's comment might be interpreted by the rest of the world as an explanation of why Canadians are so laid back, there is no truth to that rumour what-so-ever. His comments were made after a tour of Canada's only legal marijuana growing operation deep underground in an old copper mine with a bustling hydroponics lab carved out of the rock hundreds of meters below the surface. There, a dense forest of marijuana plants bask under the blinding glare of powerful halide lights. "Its an incredible experience to see this operation" said Rock. "Its obvious we have good growth", he noted. Upon his return to the surface, he cut a ribbon at the entrance of the mine as he stood beside an RCMP officer in full uniform. "Let's open this mine and get the plants to patients as soon as we can", he concluded. Interesting,

continued on page 20

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“Gold” Mine

continued from page 19

how, in the minds of some Canadian politicians, at least, there is an apparent *shortage* of marijuana. After visiting the “gold” mine (as one official put it), rumour has it that Rock and his entourage stopped for Chinese take-out, but this report could not be confirmed.

Anyway, even such apparently liberal policies have not satisfied everyone in Canada. Critics claim the exemption policy is too restrictive, that the mine won’t produce enough pot to meet the anticipated demand, and that the weed won’t be of sufficiently high quality to satisfy seasoned users. Indeed, it has also been suggested that the subterranean grow operation under contract by Prairie Plant Systems of Saskatoon, Saskatchewan is absurd. The $5.7-million price tag for the facility seems odd when most Canadians (like citizens of almost any country) can buy high-grade marijuana at discount prices in their own communities. On the other hand, the mine has prompted groups in other countries to hold up Canada’s new policy as an example of compassion that should be followed by other governments. Whatever.

So where does Canada hide its high-tech, state-of-the-art, government-run marijuana mine? It’s near the town of Flin-Flon, Manitoba (pop. 7,000), which is 650 kilometers northwest of Winnipeg near the Saskatchewan boarder. Not really much to see there - but you can buy a T-shirt proudly proclaiming the fact that you’ve visited the marijuana-growing capital of Canada. Anyway, all of this has got me thinking - I wonder how the Feds would feel about growing other “interesting” crops (for legitimate purposes only, of course) on the arctic tundra. “Hello, Prime Minister Chretien? I was thinking…”

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Coffee

continued from page 7

→ 7-methylxanthine → theobromine → caffeine as the main biosynthetic pathway in coffee (2-4). Additionally, there is a report showing the direct conversion of xantosine monophosphate into 7-methylxantosine (5).

Coffea arabica

Caffeine biosynthesis in coffee is carried out in both leaves and fruits. This is the general picture.

However, it is very interesting that for a plant so important, very little is known about the properties of the enzymes involved in the biosynthesis of caffeine and nothing of the enzymes involved in its degradation. This field of research has many opportunities to generate new knowledge. The regulation of both pathways, the determination and purification of the enzymes involved in the degradation of caffeine, the isolation and cloning of the genes coding for those enzymes, are only a few of the questions we can try to answer.

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Across the Pond

continued from page 12

for concern, especially because science thrives on exchange of people of all nationalities.

This reconstruction has also brought rapid scientific change with a steady stream of Deutschmarks (and now Euros) being spent to improve scientific infrastructure in the East. This support, and the talent it has retained and attracted, has made the IPB an extraordinary place to be doing research. Facilities, instrumentation and expertise exist for the full spectrum of plant biochemistry, from the synthesis of natural products to genomic analysis of metabolic pathways. As well, the IPB is situated within a region that includes such notable German plant research institutes as the Max Planck Institute of Chemical Ecology in Jena, the MPI of Molecular Plant Physiology in Golm and Europe's largest plant breeding institute in Gatersleben. Small meetings and both formal and informal collaborations add to the scientific opportunities here.

Of course, anyone who has visited Europe for its museums and castles knows that it is rich in history and classical culture. Halle is in the heartland of German culture: it is the birthplace of Händel, and the haunts of Bach, Goethe, Schiller and Nietsche among others are all within one-hour train ride. Martin-Luther-Universität Halle-Wittenberg, as the University of Halle is officially known, is one of the oldest in the Germany and celebrates its 500 anniversary in 2002**.** For the phytochemist, it is also worth noting that Halle is the birthplace of the alkaloid, as the term was coined in 1819 (from the Arabic "al-qaliy") by a pharmacist working in a Löwen Apotheke just off the city's main square. The pharmacy is still in operation today.

Language is probably the one factor that looms large when a young researcher considers working in Europe. Having only spent time in labs in Germany, I can only comment on the situation here. In the lab, it's not a big problem as most young German scientists speak English. Conversing with some technical staff presents more difficulties but when you consider a centrifuge is a "Zentrifuge" in German, these can be overcome. Life outside of the lab is another story, especially in Halle where the generations educated during "DDR-Zeit" (during East-German communism) learned Russian rather than English. This is when you have to put your language circuitry to work and pick up enough for the basic necessities of life. And after too much of life in the provinces one can always escape to Berlin for a movie in English.

Market Church and Red Tower in Halle.

Coming to Europe has been an interesting experience, and one that I recommend others consider when choosing where to postdoc or when providing direction to their soon-to-be-finished PhD students. Salaries are comparable with those found in Canada and the U.S. (in the range of 30 000 Euro) and you are entitled to those six weeks of paid holiday each year. There are some concerns of course; the danger of getting disconnected from colleagues in North America and ending up out-of-loop in terms of jobs back home, and the need to endure long flights and jetlag to attend meetings and visit family. There are several funding programs aimed at bringing scientists from abroad to Germany to do research, such as those offered by the prestigious Alexander von Humboldt Foundation (visit www.avh.de, which is aimed primarily at postdocs and established scientists or try the DAAD Web site www.daad.de, which is aimed more at graduate students).

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Elsevier Publishes Volume 35 of Recent Advances in Phytochemistry

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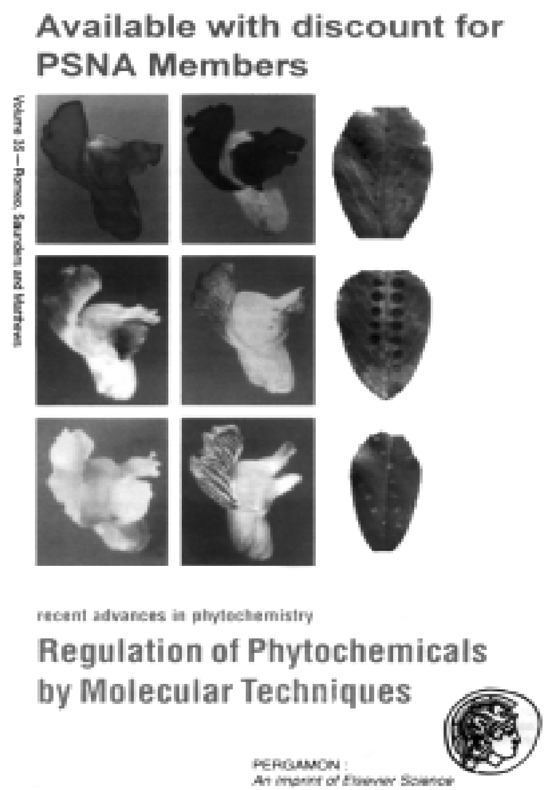

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