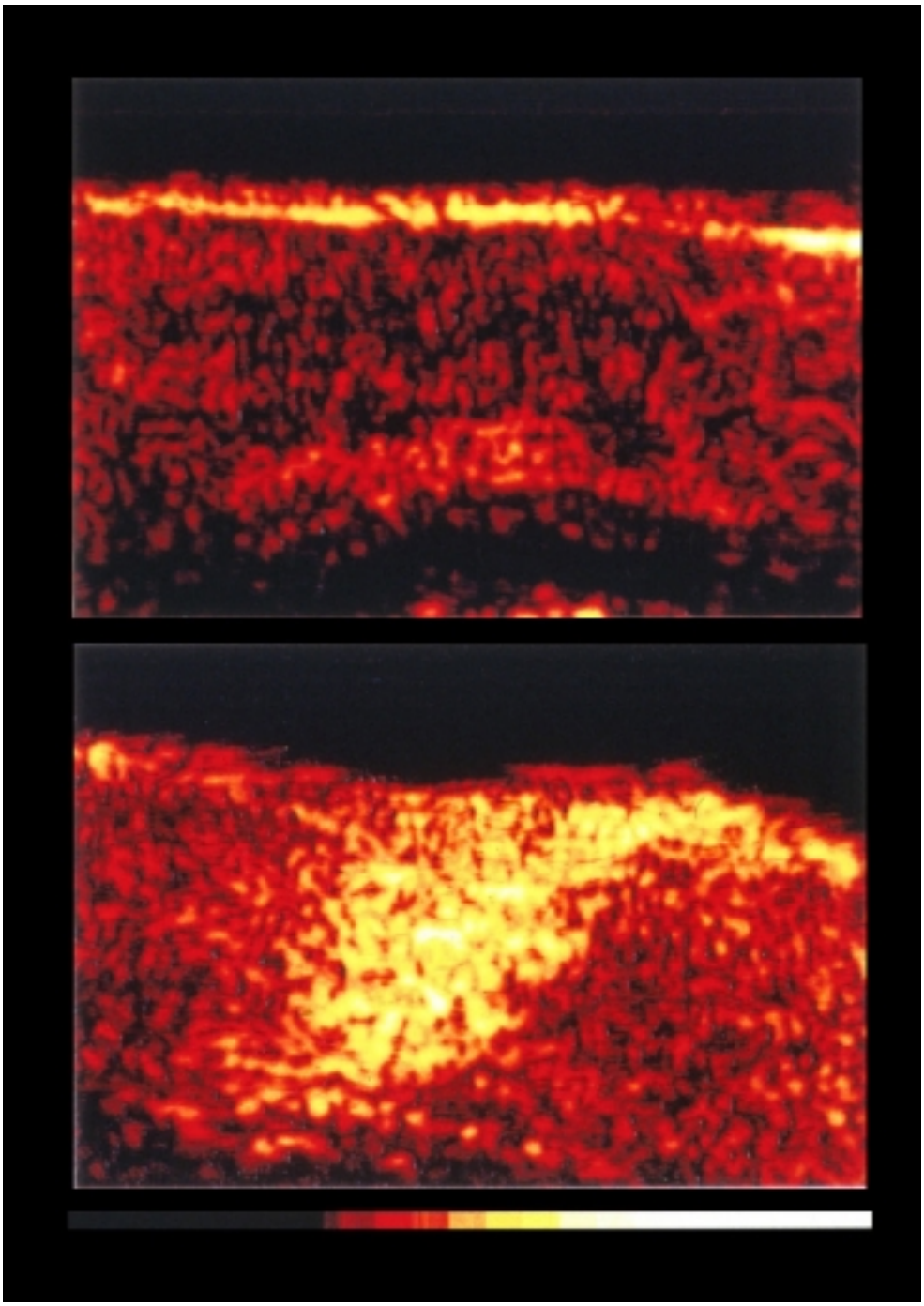
InterACTIONS

CANADIAN MEDICAL PHYSICS NEWSLETTER
Le BULLETIN CANADIEN de PHYSIQUE MÉDICALE



Acoustic Treatment Monitoring

COMP OCPM

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About our Cover

Acoustic Treatment Monitoring: Images from the brain of a rat treated with photo dynamic therapy (PDT). The Photofrin drug was administered systemically and the light treatment was applied to brain using a contact optical fibre. The brain was removed from the rat 24 hours after treatment and imaged using 40 MHz ultrasound. The upper image is an untreated area of the brain and the lower image is the treated area. Each image is 4 mm x 4 mm in dimension.

The results show the potential of using high frequency ultrasound imaging to non-invasively monitor the effects of chemotherapeutic agents and other anticancer treatments in experimental animals and in patients. The enhanced ultrasound backscatter is due to subcellular nuclear changes, such as condensation followed by fragmentation, that cells undergo during apoptosis. These changes dramatically increase the high frequency ultrasound scattering efficiency of apoptotic cells over normal cells (25- to 50-fold change in intensity). The result is that areas of tissue undergoing apoptosis – as a result of treatment with an anticancer agent – become much brighter in comparison to surrounding viable tissues. In the future, high frequency ultrasound could be used to monitor the effectiveness of anticancer agents by scanning for apoptotic regions in patients. Along with Stuart Foster at Sunnybrook and Women's Hospital, the researchers plan to develop a needle-like ultrasound probe that can be inserted into the body. For more information see: G.J. Czarnota, et. al. Br J Cancer, **81**: 520-7 (1999).

Figures courtesy of Dr. Michael Sherar, Senior Scientist, Ontario Cancer Institute / Princess Margaret Hospital and Assistant Professor, Department of Medical Biophysics, University of Toronto.

The Canadian Medical Physics Newsletter, which is a publication of the Canadian Organization of Medical Physicists (COMP) and the Canadian College of Physicists in Medicine (CCPM) is published four times per year on 1 Jan., 1 April, 1 July, and 1 Oct. The deadline for submissions is one month before the publication date. Enquiries, story ideas, article submissions, and advertising submissions can be made to:

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Please submit stories in Publisher 98, Word 6.0, Word 97, or ASCII text format. Hardcopy submissions will be scanned to generate an electronic document for inclusion in the Newsletter.

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Message from the COMP Chair:

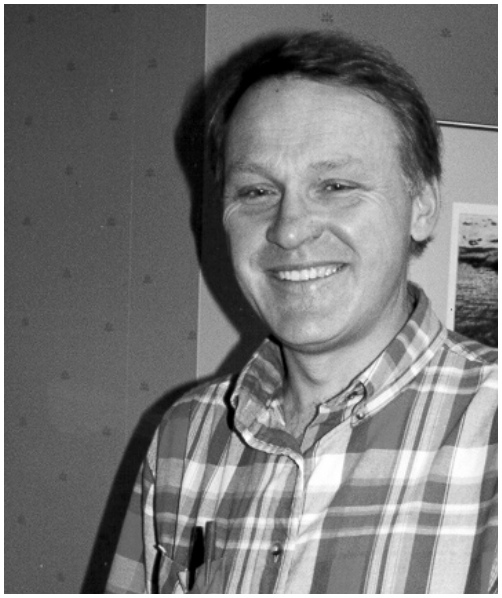
I should emphasise that we were unable to hold a block of rooms at the hotel without putting money up front, so you should reserve accommodation early. COMP will also be offering $250 to any member whose paper is accepted for the World Congress Young Investigators Competition.

Well, this is my last message of the 1900's. You will notice that I have refrained from calling it my last message of the millennium because I know that many of our members are purists who would not hesitate to point out my counting error. I hope you are reading this in the comfort of your office or home and not by candlelight after fighting with your neighbour over the last scrap of frozen bread in the dark city. Many of us have spent so much time planning for Y2K that the actual event, however disastrous, can only be a relief!

Your executive recently spent a busy day and a half in Ottawa conducting our usual midyear meeting. This was the first chance for our new executive director, Brighid McGarry, to meet the rest of the executive and to become acquainted with the inner workings of the organization. As well, Brighid played a big role in organizing the accommodation, meals, and agendas, and I can almost feel a large weight beginning to shift from my shoulders. I am sure COMP made the right move in creating this position and that our organization will continue to benefit in the future. I would also like to welcome Barb Callaghan, our new secretarial assistant, to COMP. Next year, when Gino Fallone takes over as Chair, Edmonton will truly become the centre of the universe.

Before I update you on a few items of business from the midyear meetings, I should follow up on a statement I made at the end of my last message. At that time I was very optimistic that our 2001 conference in Kelowna would be held in conjunction with CARO, the Canadian Association of Radiation Oncologists. Unfortunately, this has not come to fruition, due to scheduling problems. CARO remains interested in a joint meeting, however, and we will work toward this in the future. Still on the topic of conferences, I can now happily confirm that our Sherbrooke meeting did realize a profit – COMP's share will be about $5700. Looking to next summer and the World Congress in Chicago, you should have received a message from COMP with details of interest to Canadians. In particular, we have identified a "Canadian" hotel (the Days Inn, eh?) where our committee meetings and the CCPM exams will take place prior to the scientific sessions. It will also be the location of a Canadian reception to be held in the rooftop (and rotating!) Pinnacle Room. I should emphasise that we were unable to hold a block of rooms at the hotel without putting money up front, so you should reserve accommodation early. COMP will also be offering $250 to any member whose paper is accepted for the World Congress Young Investigators Competition.

In Ottawa, Peter O'Brien provided the executive with an update on AECB's quality assurance initiative in radiation therapy. The executive agreed to review QA standards which are being developed and to consider the establishment and maintenance of a database on radiation therapy incidents. The executive received the first draft of a report from the TG 51 task force and some suggestions for revision have been sent to its chair, Ervin Podgorsak. It is hoped that a final version will be published in the April newsletter. Three



bylaw changes were recommended for approval by the members at our next general meeting and a detailed description of these can be found elsewhere in this issue of *Interactions.* Our secretary, Curtis Caldwell, has succeeded in having all of our previous bylaw changes approved by Industry Canada. We have recruited two new corporate members and Brighid is rapidly taking over corporate relations as part of her portfolio. One item of concern at the meeting was the realisation that many of our committees are in need of transfusion…preferably new and young blood! If you would like to become involved in the activities of the Professional Affairs Committee, the Communications Committee, or the Radiation Regulations Committee, I suggest you contact the chairs (see your directory). They would be more than happy to describe what the committees do and how your expertise and interests might fit in.

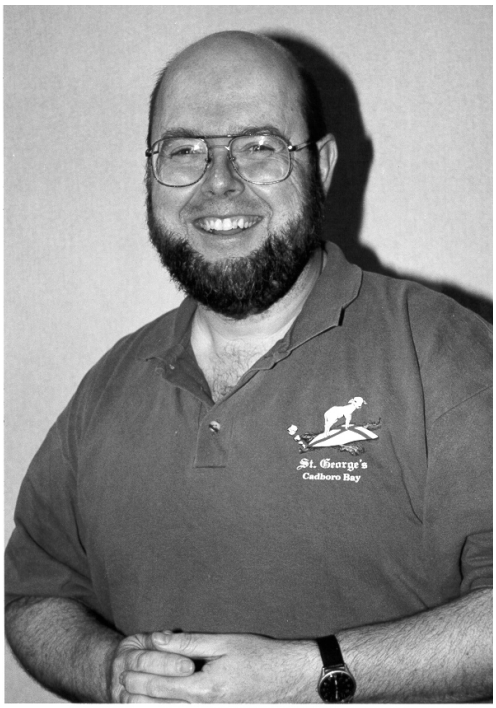
Finally, I note that the end of 1999 is the end of Michael Evans' term as treasurer of COMP. In

(Continued on page 21)

Message from the CCPM President:

I am writing this approximately one month after the 1999 Ottawa mid-year meetings of the CCPM Board, and the COMP and the Joint CCPM/COMP executives. The meetings went well and the excellent operating relationship we have had with COMP for the last few years continues.

One of the highlights of the board meeting



was the opportunity for many to finally meet face to face with Brighid McGarry our Executive Director. It became quite clear as the meeting progressed that Brighid will be able to help the College in many of the efforts we are undertaking, and we welcome her expertise.

A number of the issues discussed by the Board were introduced in the last issue of Interactions. The documentation of policies and procedures for the College continues; Peter Dunscombe has prepared a good working draft and the Board members are now helping to fine tune the documents.

Brenda Clark and Katarina Sixel have worked hard to prepare a proposed guideline summarizing the College's view for the training and assessment of medical dosimetrists. The guidelines are being refined; if anyone would like to have some input into the document I would ask that you contact Brenda or Katharina for a copy. Additional input would be appreciated.

In my last message, I asked for support for the College representation in the activities of the Conjoint Accreditation Service of the Canadian Medical Association. The CAS is very keen to have medical physics input in training program site visits, and I believe we must ensure that medical physics is represented in the evaluation of these training programs. Please consider volunteering for this important work. If you require any additional information please contact Brenda Clark who, as vice-president, is the Board's liason with the CAS.

I would like to inform you of the continuing interactions between the CCPM and CAMPEP, the Commission on the Accreditation of Medical Physics Education Programs in the United States. I am happy to report that the Board of CAMPEP agreed during the last RSNA that the CCPM should be made a sponsoring body of CAMPEP (you may have read about this in the November-December issue of the AAPM Newsletter). The Board of CAMPEP is now asking for ratification of this decision by the current sponsoring bodies: the American Association of Physicists in Medicine, the American College of Radiology and the American College of Medical Physics. The College Board is pleased that these initiatives are proceeding quickly, and I suspect that I will be soliciting shortly for volunteers to represent the CCPM on various CAMPEP committees.

Finally, an issue which will start to become more important in the next couple of years is re-certification. We on the Board are beginning to address those parts of the process which will require our work. I would ask that you also review the requirements for re-certification so that you can assess how the process will effect you in the next few years (see page 53 of the COMP/CCPM membership directory). In anticipation of the work we are improving our membership database.

I wish you all the best of the Season and a prosperous New Year as we move ahead in medical physics in Canada.

L. John Schreiner

One of the highlights of the board meeting was the opportunity for many to finally meet face to face with Brighid McGarry our Executive Director. It became quite clear as the meeting progressed that Brighid will be able to help the College in many of the efforts we are undertaking, and we welcome her expertise.

Cancer Care Ontario Wins a 1999 Canadian Information Productivity Award for Virtual Simulation

By Kathy Mah

It was a night to remember. A banquet with Knowlton Nash as Master of Ceremonies. Rubbing shoulders with the whose who in Canadian business. The envelope please….and the winner is…! So what is a physicist doing in a scenario like this?

The night was Monday November 8, 1999 and the place was the Westin Harbour Castle Hotel in Toronto. Approximately 1800 people had gathered for the black tie, gala event, the 7th Annual Canadian Information Productivity Awards (CIPA). Cancer Care Ontario (CCO) was there to accept a 1999 National Award of Excellence for effective implementation of Virtual Simulation technology. CCO also won the BEST IN CATEGORY Award for non-profit institutions. (Those 3D graphical movie loops - that were part of the application - must have been good for something after all!) These awards recognize the best information technology (IT) practices in Canada, the organizations who have used information technology for the benefit of stakeholders (in this case, the patients) as well as for advances in productivity within the institution itself. The awards were graciously accepted by Dr. Tom McGowan, Director of Radiation Treatment Programs for CCO, amid cheering from 50 staff and guests from CCO, Picker International Canada, Inc, and GE Medical Systems, Canada. CCO was honoured to receive a national business award amid such innovative and prestigious recipients. The winners' gallery showcase for all award recipients is located on the CIPA website at http://www.cipa.com/.

Some of the award winners. Left to right: Cyril Danjoux, Radiation Oncologist; Vivienne Ali, Planning Process Coordinator; Gerard Morton, Radiation Oncologist; Kathy Mah, Physicist; Rose Lisi, Administrative Assistant; Sharan Manship, Radiation Therapist; Amanda Bolderston, Clinical Educator.

Toronto-Sunnybrook Regional Cancer Centre (T-SRCC) with the Picker ACQSIM CT-simulator was the first centre in Ontario, second in Canada (Montreal General Hospital was the first), to implement this technology and the lead site in the CIPA application. Dr. McGowan with help from Mr. Peter O'Brien, Mr. Jake Van Dyk, Mr. Garth Matheson, and Dr. Catherine deMetz, submitted the application on behalf of T-SRCC, the London Regional Cancer Centre (Picker ACQSIM system), the Northwestern Ontario Regional Cancer Centre (GE ADVANTAGE SIM workstation) and the Windsor Regional Cancer Centre (GE ADVANTAGE SIM workstation), respectively. Without an on-site CT scanner, the latter two centres have developed innovative partnerships with their host hospitals made possible with this technology. As described in the application, the key objectives of virtual simulation as an IT solution are:

1. To improve the accuracy and precision of target and normal tissue definition for radiation therapy planning.
2. To allow oncologists (by improving geometric accuracy) to increase the dose delivered to the tumour and to increase control rates without increasing side effects.
3. To allow the development of innovative treatment plans that could not be developed using 2-D techniques through the use of 3-D visualisation.
4. To increase the efficiency of the planning process by reducing the number of steps involved.
5. To reduce the number and length of visits that the patient had to make to the Cancer Centre for the planning of their radiation treatment.

At T-SRCC, CT-simulation has revolutionised the planning process and provided a means to perform accurate 3D localisation of both targets and critical structures, paving the way for true 3D conformal radiotherapy and intensity modulated radiotherapy (IMRT). For some patients, appointments in planning

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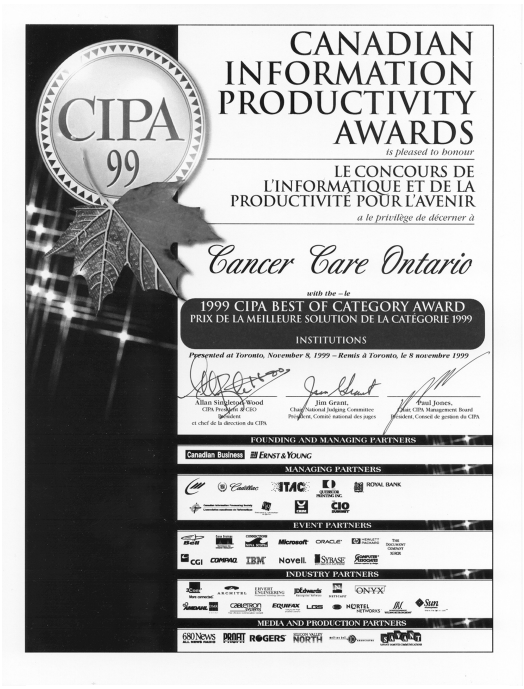
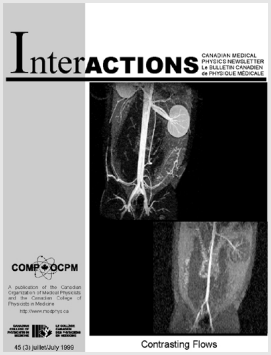
have been reduced to a single half-hour visit from as many as three visits. More importantly, the potential benefits of this technology for patients are just beginning to emerge.

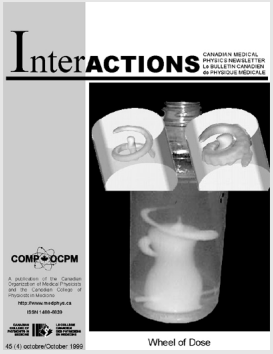
At T-SRCC, the effective implementation of this technology was truly a multi-disciplinary team effort. The success of the CT-simulation program would not have been possible without the ardent support and co-operation of all staff in the Radiation Program. Special recognition must be given to Peter O'Brien, Head of Medical Physics whose foresight and enthusiasm for this technology paved the way for the 1996 acquisition of the system. The CT-simulation technical team has demonstrated both hard work and talent. Team members include Marlene Cardoso, Dosimetrist; Sharan Manship, CT-simulation Therapist; Bob MacKenzie, Radiation Oncologist; Kathy Mah, (Chair) Planning Physicist; Gerard Morton, Radiation Oncologist; Katharina Sixel, Planning Physicist; and Stanley Wong, Dosimetrist.

Although not all team members were able to attend the gala, T-SRCC was well represented. Its staff exuded great enthusiasm and pride, a reflection of their support for the CT-simulation technology. A great time was had by all!



The CIPA Award of Excellence





WANTED: Editor for Interactions

The COMP Communications Committee is looking for a person to become responsible for the publication of Interactions. Web site management and the co-ordination of the Communications Committee (also the job of the current editor) will become a separate task performed by the Chair of the Communications Committee. COMP can offer the same conditions that Canadian medical physicists have long been accustomed – low salary, long hours, no benefits, lots of complaints, and limited praise. There's no life like it!

The position becomes available on 2 July, 2000.

If interested in this challenge please contact the Chair of the COMP Communications Committee at:

peter.munro@lrcc.on.ca

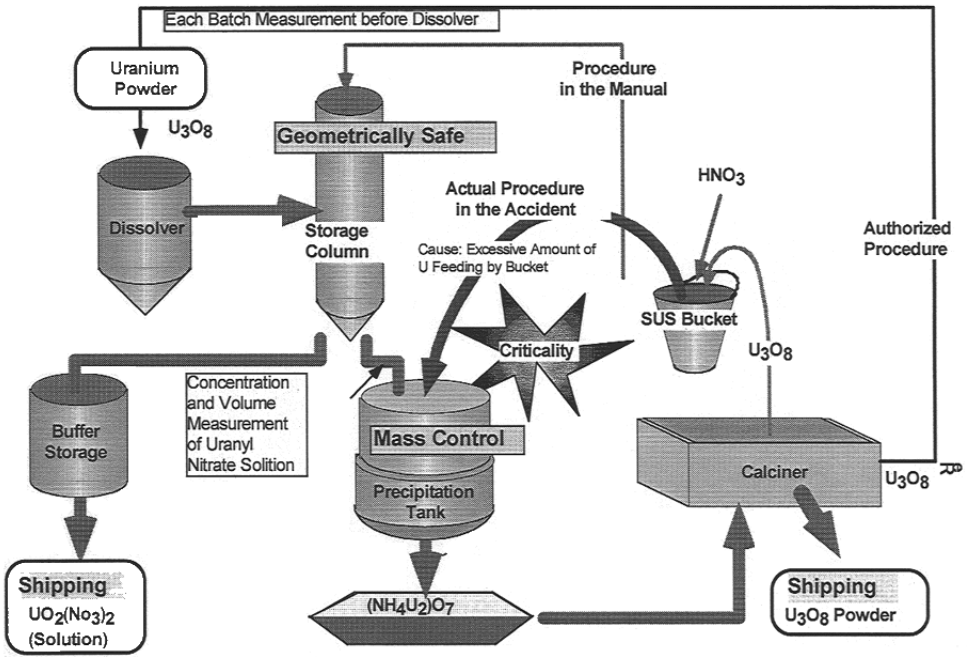
The Flash at Tokaimura

By Peter Munro, Dr. Vitali Moiseenko, and Dr. David Lloyd

Editors note: Dr. Moiseenko is a research associate at the London Regional Cancer Centre and Dr. Lloyd is the Head of the Cytogenetics Group at the National Radiological Protection Board (NRPB) in the U.K.

At 10:30 a.m. on the 30 Sept. 1999 three workers at the JCO uranium processing plant in Tokaimura, 110 kilometers northeast of Tokyo, were exposed to extremely high levels of radiation when they accidentally dumped more than six times the safe amount (~16 kg) of MOX (**mi**xed uranium plutonium **ox**ides) fuel into a processing container. A total of 49 people including 24 JCO workers who helped drain the processing container, three fire fighters engaged in the rescue operation, and local residents were exposed to elevated levels of radiation. Unwittingly, the three workers involved in the accident had constructed a mini nuclear reactor - without safety controls or shielding. The accident occurred near the final stages of generating uranium nitrate for Japan's Joyo experimental fast-breeder reactor.

The production of uranium nitrate is carried out in two stages. First the fuel is ground and sieved to remove large contaminants. Then the fuel is dissolved in nitric acid, filtered, and precipitated in a holding tank, with any dissolved waste materials being removed while still in solution. Normally, this second process is carried out in a cylindrical tower that limits the quantity of fuel that can be mixed and dissolved, thereby preventing a critical mass of fuel - sufficient to support a chain reaction - from reaching a precipitation tank (see Fig. 1). Unfortunately, the JCO company had adopted a series of procedures that, illegally, bypassed many of the safety procedures. The operators were encouraged to mix the uranium fuel and nitric acid by hand in what were equivalent to ten-litre stainless-steel buckets. They were then allowed to dump the contents of these buckets directly into the precipitation tank - a vessel not designed to prevent the accumulation of a critical mass of fuel.



Schematic of the process used to generate uranium nitrate by the JCO company.

Unlike conventional light water reactors, which use uranium oxide containing 3% ^{235}U, the Joyo fast-breeder reactor (so called because it should produce more fuel than it consumes) uses fuel containing plutonium and highly enriched (18.8% ^{235}U) uranium oxide. [Surrounding the core of MOX fuel is ^{238}U, which is converted to ^{239}Pu by neutrons released from the fission reaction occurring in the core.] The workers mixing the fuel, two of whom had never made Joyo fuel before, were probably unaware that they were handling fuel containing six times as much fissile uranium as normal. The only warning that the workers received that an accident had occurred was a blue flash - Cherenkov radiation generated by the chain reaction occurring in the liquid of the precipitation tank.

The JCO company was ill prepared for a criticality event. Indeed, in their operating license the company had stated that because the amount of nuclear fuel would always be carefully weighed there was no chance of a criticality event. And thus the plant needed no form of containment. So, when the accident happened, the radiation dose rate at the nearest point on the site boundary (about 90 metres from the stricken building) increased to 0.84 mSv/h gamma and 4.0 mSv/h neutron. Early on and close in the gamma dose rate was due to direct gamma radiation generated by the chain reaction. Further afield a maximum gamma dose rate of 3.1 μGy/h was measured at 1.5km downwind, to the south, at 5.5h after the chain reaction began. Here the radiation was due to a plume of radioactive noble gases and iodine borne by the wind, which was released via the building's ventilation system. These conditions forced the evacuation of residents living within a 350 m distance from the facility and forced residents living within 10 km of the plant (more than 310,000 people) to stay indoors for 24 hours. Inside the plant things were little better. The three workers who "caused" the accident were not wearing personnel radiation monitors so their radiation exposures had to be determined using alternative techniques. And stopping the chain reaction proved difficult. Working in shifts of a few minutes at a time to limit their exposure, workers had to smash the pipes that lead to a cooling jacket, which surrounded the precipitation tank. The water in the cooling jacket was acting as

(Continued on page 9)

The Flash at Tokaimura *(Continued from page 8)*
a neutron reflector that helped maintain the chain reaction. To further ensure that the reaction stopped, neutron absorbing boron compounds were also pumped into the precipitation tank. Nevertheless, the operation to stop the uncontrolled chain reaction did not start until 3:00 a.m. on 1 Oct. 1999 - about 16 hours after the accident.

While the accident was a tragic event for the three workers most directly involved, it was an opportunity for the international radiation protection community to test the effectiveness of several dosimetry techniques including both biological and physical dosimetry.

One of the well established methods of biological dosimetry is based on estimating the frequency of chromosome aberrations in peripheral blood lymphocytes (more exactly PHA responsive T cells). This approach has many advantages including: chromosome aberrations that are specific to exposure by ionising radiation; a low frequency of spontaneous occurrence for these aberrations; and; small inter-individual variability in dose response. Mature lymphocytes are also good biological dosimeters because they do not divide and they remain in the body for extended periods (half-life of 3 years). Traditionally, lymphocytes are stimulated to proliferate, are harvested 48 hours later when they are at metaphase (by inhibiting mitosis) and are analysed for chromosome aberrations. However, the high radiation doses from the Tokaimura accident would have prevented most lymphocytes from reaching mitosis. Therefore, as well as using the conventional "metaphase" technique, an alternative method, known as the premature chromosome condensation (PCC) technique was also used to condense the chromosome material. Somewhat prophetically, a new PCC technique, designed for very high dose accidents where it is difficult to get metaphases, was published just three months before the accident [R. Kanda, et. al., Int J Radiat Biol. 75(4) 441-446,1999]. This new method, using a condensation inducer called okadaic acid, gave good agreement with the doses estimated using the conventional "metaphase" technique.

In addition, physical dosimetry, based on the activation of sodium was also used. [For a comprehensive review of this technique see: W.G. Cross et.al. Radiat. Prot. Dosim. **10:** 256-276 (1985).] When a person is irradiated by neutrons, between 15-35% of the incident neutrons are thermalised and captured in the body, resulting in induced activity. Because of its relatively long half-life (15 hours), several hours after the accident, ^{24}Na is the predominant source of activity. The Tokaimura accident was ideal for this technique because at a depth of 8 cm, Japanese investigators estimated that 70% of the dose was from neutrons. Remarkably, dose estimates obtained by biological and physical dosimetry methods were very close. The estimates suggest that the three workers received 17, 10, and 3 Gy gamma equivalents (a gamma equivalent assumes an RBE of 1.7 for neutron exposure at high doses).

At the time of writing all three workers are still alive, even though the two of the workers received such high doses. The survival of the two most highly exposed workers for such a long period after the accident suggests that the radiation dose was highly non-uniform - resulting in sparing of the workers' gastro-intestinal tracts. [At whole body doses above 4-8 Gy, the expectation is that people will die from injury to the gastro-intestinal tract before the haematopoietic injuries manifest themselves.] The men have received excellent medical attention. The men have received cytokines and transfusions of stems cells (the 17 Gy equivalent man received stem cells from a well matched sister). However, their medical prognosis, especially for the 17 Gy equivalent man, is grim. Even if the medical staff are able to nurse the men past the sub-lethal injuries to their many body systems, radiation pneumonitis may prove lethal. Radiation pneumonitis, which generally manifests itself 3-6 months after radiation exposure, has an LD/50 of about 10 Gy.

This accident raises many concerns about the Japanese nuclear program. The problem does not seem to have been risks of the task itself (producing fuel for the Joyo fast-breeder reactor is not as risky as many other activities in the industry) but in the lack of compliance with safety procedures and a lack of vigilance in maintaining standards. It remains to be seen if the Japanese nuclear power industry, like this accident at Tokaimura, is "over in a flash".

Unfortunately, the JCO company had adopted a series of procedures that, illegally, bypassed many of the safety procedures. The operators were encouraged to mix the uranium fuel and nitric acid by hand in what were equivalent to ten-litre stainless-steel buckets.

Radiotherapy in the Next Century: Ten Megatrends

By J. J. Battista
London Regional Cancer Centre

Editors note: This is the first of a series of articles examining some of the changes that can be expected in the field of medical physics in the new millennium. This has been adapted from the article originally published in ADVANCE for Administrators in Radiology and Radiation Oncology, 9(10): 46-54 (1999).

Introduction

The aim of radiotherapy has always been to improve the quantity and quality of life for cancer patients. The purpose of this article is to forecast the future of radiotherapy in light of new technology[1,2]. The trends that have developed during this century **(see Table I)** will serve as a springboard for predicting the future wave of developments.

Trend # 1 - Towards a doubling in radiotherapy caseload in 15 years

The annual rate of cancer incidence in North America is approximately 450 new cases per 100,000 population and the mortality rate is approximately half of the incidence rate. In the American population, this corresponds to over 1.2 million new diagnoses and approximately 570,000 cancer-related deaths per year. **Figure 1** plots the projected increase within Ontario[3] with a sample population of 11 million people. While the annual population growth is approximately 1%, the rate of increase in cancer cases is higher - *4.5 % per annum*, compounding into a doubling of cases every 15 years. Smoking habits and environmental "gaffes from the past" account partially for the rise but the major factor is probably demographics - the incoming wave of maturing "baby boomers". In addition there are improved cancer screening programs, leading to earlier detection of cervix, breast, and prostate disease.

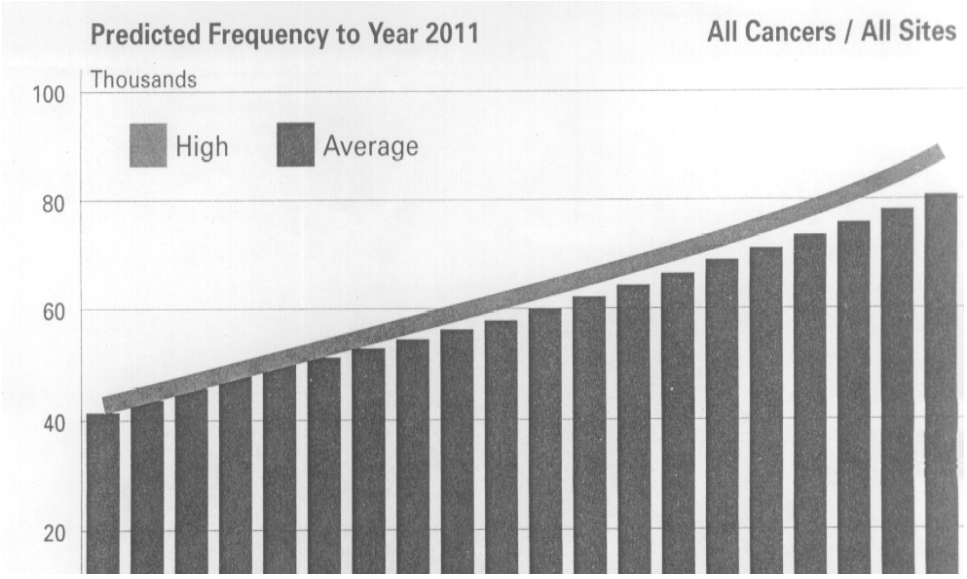


Figure 1. Incidence of cancer cases in the Ontario. Adapted from reference 3.

These projections would be negated if a scientific breakthrough were to yield a universal "magic bullet" to cure all cancers. While significant progress is being made in the molecular biology of cancer, their application to preventive, diagnostic, or therapeutic strategies will require several decades of development[4]. Therefore, it is reasonable to expect that cancer treatment will be needed well into the next century.

Trend # 2 Towards better Tumour 'Targeting'

The following dictum from the past still captures the essence of radiotherapy:

"If you can't see it, you can't hit it; If you can't hit, you can't cure it"

Rapid advances in 3D digital imaging such as CT, MRI, ultrasound, and nuclear medicine (SPECT, PET) have greatly improved our ability to localise the gross disease. However, today's imaging techniques have resolutions of approximately 1 mm which is inadequate for delineating *microscopic* extensions

(Continued on page 11)

Table 1. Summary of Ten Megatrends in Radiotherapy

Trend # 1	Towards a doubling in radiotherapy caseload in 15 years
Trend # 2	Towards better Tumour 'Targeting'
Trend # 3	Towards a 4-dimensional (4D) view of the patient
Trend # 4	Towards greater use of virtual reality technology
Trend # 5	Towards more utilization of X-rays rather than radioisotopes
Trend # 6	Towards more dynamic beam techniques
Trend # 7	Towards greater use of Monte Carlo methods for dose prediction
Trend # 8	Towards 3D dosimetric gel imaging
Trend # 9	Towards clinical radiobiology
Trend # 10	Towards more image-based quality assurance of the patient

of the disease, since the cell density is approximately a million cells/mm^3. In the future, sensitive nuclear imaging techniques such as advanced SPECT or PET scanning may detect sub-populations of migrant cells, using perhaps human monoclonal antibodies as tumour cell beacons. These imaging methods are currently underused in radiotherapy applications.

Trend # 3 Towards a 4-dimensional (4D) view of the patient

Natural physiological cycles such as respiratory motion can affect the layout of the target and normal tissues during a course of treatment. This leads to the notion of a 4-dimensional model of the patient, in which the anatomy is mobile and changing with time. In today's clinical practice, the "planning target volume" encompasses not only the detectable disease, but also includes a geometric safety margin to account for movement and uncertainties in repeated patient setups. This approach may unnecessarily expose adjacent normal tissues and place them at risk for complications. Fiducial markers or small transmitters into the tumour bed during surgery may help with subsequent tracking of motion by imaging techniques or external sensors. "Stroboscopic therapy" can then be applied so that the radiation is activated only when the target is within the "hit zone". Such approaches are being developed for respiratory motion which is either monitored or temporarily halted during gated radiotherapy.[5]

Trend # 4 Towards greater use of virtual reality technology

The radiotherapy simulator, CT scanner, and treatment planning workstation are the main tools for planning the optimal treatment and for predicting dose distributions. Networking and 3D computer graphics allow merging of image data sets and 'roaming' through the anatomy, beams, sources, and dose maps[6] (Figure 2). This approach, however, is performed to a much greater extent in the entertainment industry and in computer-aided engineering. It is expected that similar approaches could be applied, for example, to the optimal placement of treatment beams within an *animated* (4D) virtual patient. The educational value of using such visualisation tools in the training of future specialists in the field of radiotherapy should **not be overlooked.**

Trend # 5 Towards more utilization of X-rays rather than radioisotopes

The era of megavoltage therapy unfolded on October 27, 1951 in London, Canada, following the pioneering work on Cobalt-60 machines by the late Dr. H.E. Johns. While there remains some role for Cobalt-60 units[7], there is pressure to reduce the use of highly radioactive substances, placing greater emphasis on passive radiation-emitting devices. Many Cobalt-60 machines are now being retired and replaced with linear accelerators which produce high energy X-rays or electron beams. Ultimately, accelerators will dominate as the primary mode of producing treatment beams because of their greater versatility and their more advanced options. Technological progress will focus on accessories, including beam shapers (e.g. multileaf collimator), beam intensity modulators (e.g. dynamic collimators), and image-guidance (e.g. electronic portal imaging). These will allow delivery of 3D dose distributions which conform tightly to the target volume, to an extent which competes with the capability of heavy particle beams[8]

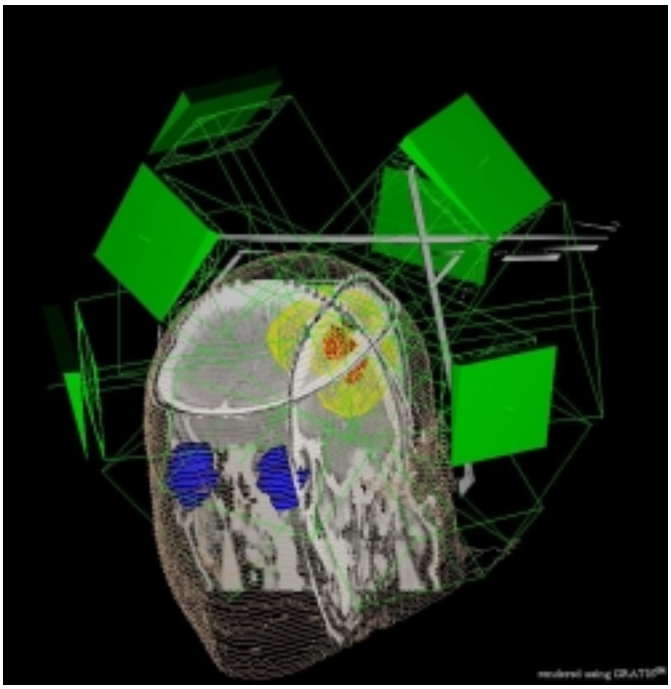


Figure 2. A virtual simulation for treatment of an intracranial lesion. The various treatment beam edges are shown in green with wedge attenuators and intersecting the tumour (red) in a virtual patient. In the future such images of the patient will be animated (4D) to visualise internal motion (e.g in the thorax). Adapted from Reference 6.

In brachytherapy, radiation protection of staff and of the patient's family has led to the use of lower energy sources such as Palladium-103 and Iodine-125. There are new possibilities emerging from the development of miniature X-ray tubes[9] with radiation that can be switched off, and adjusted in energy and dose rate. Future brachytherapy procedures may be performed with this type of technology, provided that the tumour can be accessed along straight-line pathways. The variable X-ray energy also permits the technique of "Photon Activation Therapy"[10] combining radiation with K-edge radiosensitizing drugs. When cells are exposed to the optimal energy (e.g 100kV$_p$), the enhanced damage to DNA leads to greater cell killing in rapidly-proliferating tumours which have preferentially incorporated the radiosensitizing drug.

Trend # 6 Towards more dynamic beam techniques

Robotic technology has been used extensively in brachytherapy to position radioactive sources safely and optimally within the tumour bed. Similarly, complex beam shaping and beam intensity modulation, which together make the 3D dose distribution optimal for each patient, require computer controls. Multileaf collimation will be standard on most accelerators, with the cost having been justified by the avoidance of shielding blocks and better patient throughput. In addition to beam shaping, the beam in-

(Continued on page 12)

tensity can be intentionally varied or "modulated" (i.e. IMRT) to produce optimal dose distributions with beam attenuators moving during exposure. The future Tomotherapy machine[11] is a specialised machine designed specifically for "slice-by-slice" irradiation. A fan-shaped narrow beam is interrupted by tungsten fingers that are placed either "in or out" of the beam during exposure. This machine resembles a spiral CT scanner and is currently being developed at the University of Wisconsin (**Figure 3**). It features a compact accelerator (6MV X-rays) with an on-board imaging detector for CT verification purposes. This type of design might dramatically streamline the procedures used today for treatment planning, delivery, and dose verification by offering a more integrated approach.

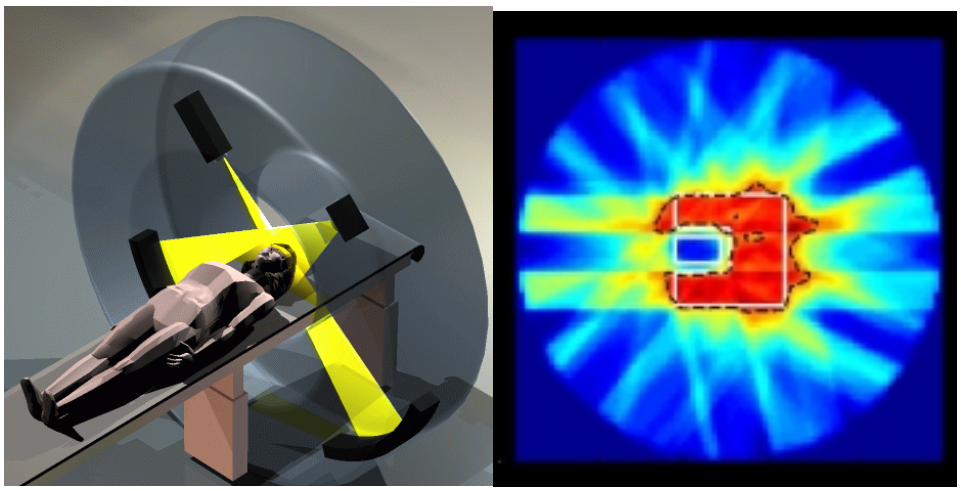


Figure 3 Future Tomotherapy machine allows "slice by slice" therapy with on-board spiral CT imaging. The complex dose distribution on the right shows pattern of high dose wrapping around a lower dose region. Clinically, this could be useful for tumours which surround the spinal canal. (Photos courtesy of T.R. Mackie, TomoTherapy Inc, Madison, WI). See reference 11.

Trend # 7 Towards greater use of Monte Carlo methods for dose prediction

It is important to compute 3D dose distributions accurately, accounting for the variable penetration and scatter of radiation within inhomogeneous tissue. The Monte Carlo method[12] simulates the passage of *individual* radiation particles within the accelerator head and the patient. This technique has in the past required long execution times unacceptable for interactive treatment planning, but this disadvantage will be overcome by relentless gains in computer speed.

Methods of dose computation have assumed a static anatomy, as imaged *before* treatment, with some ad-hoc allowances being made for expected movements and for inevitable uncertainties in daily patient set-ups. The next generation of algorithms will incorporate the capability of "4D dose" prediction, allowing for moving tissue compartments and for the associated blurring of the dose pattern (**Figure 4**).

Trend # 8 Towards 3D dosimetric gel imaging

More efficient and more direct 3D dose mapping is needed to validate the dose predictions made with treatment planning computers and the dose distribution delivered by new treatment techniques. Today's dosimeters allow either point spot checks or planar measurements using film exposures. With the advent of new dynamic irradiation techniques that produce complex 3D dose distributions with larger dose gradients in all possible directions, these methods are becoming limited or inefficient in their applicability. Radiochromic and radiopolymerizable gels inserted into humanoid phantoms are now being developed to record doses in 3D and these can be read as dose images using either MR or optical CT imaging[13] (**Figure 5**). In the ultimate configuration, the phantoms could include moving elements to simulate organ motion such as lung and tumour movement. With such verification, confidence in the technology of accelerators will increase and more innovative techniques will emerge for optimal treatment of individual patients with higher dose radiation.

Trend # 9 Towards clinical radiobiology

It is recognised that the physical dose distribution and dose-volume data are necessary but not sufficient as predictors of cellular response to radiation. Radiation biology has contributed to fundamental understanding but until now the applicability to human tumours in an individual cancer patient has been limited. However, recent developments of *in vivo* predictive assays, which measure tumour doubling times[14], DNA damage and hypoxic cell fractions[15] in solid tumours (**Figure 6**). In the future, optimal dose prescriptions and fractionation schemes will be based on radiobiological parameters measured from a biopsy specimen. Human radiobiology will also be much easier to analyse on the basis of pre-treatment biological conditions for each patient. These findings will help to redefine models of predicting tumour control (i.e. TCP) and complication rates (i.e. NTCP).

Trend # 10 Towards more image-based quality assurance of the patient

In achieving consistency in clinical outcomes (and in reducing the exposure to litigation) the need for quality assurance will remain very strong in the next century. The most direct and interpretable form of patient-specific verification of treatment is that of an image acquired before or during the treatment delivery procedure. From this perspective, the application of video camera monitoring[16] and electronic portal imaging[17] will continue to improve. A calibrated CT imager can further serve as an exit dosimeter to reconstruct the 3D dose distribution "as delivered" inside the patient[18]

What % of cancer patients will benefit from new technology ?

Realistically, the new technology, asso-

(Continued on page 13)

ciated procedures and staffing are costly and they will not benefit *every* cancer patient. A triage of patients will be necessary to cope with the anticipated increase in clinical caseload and workload and it will be important to focus the 3D technology on patients who are most likely to benefit. Sixty-eight percent (68 %) of patients who are initially diagnosed (100%) present with potentially curable localised disease[19]. Of these patients, two-thirds of tumours are controllable today by combinations of surgery, chemotherapy, or radiotherapy. Radiation plays a significant role in controlling 25 % of the diagnosed cases, but one-third of the tumours treated with radiation will have recurred (i.e. 8% of diagnoses). Thus new targeting approaches are aimed at this 8 % subpopulation of patients who are failing at the initial site of treatment due to geographic or dosage inadequacies. In the United States alone, 8 % of the newly-diagnosed population corresponds to approximately 100,000 patients annually who might be treated more successfully in an initial course of aggressive curative radiotherapy. To be fair on this issue of estimates and expectation, the reader is cautioned that the optimistic viewpoint is counterbalanced by some negativism[20]. What is realistically achievable with the new radiotherapy technology will only become apparent and "proven" after several years of controlled clinical trials. There is mounting evidence[21] that new high-dose treatment techniques are improving 5-year survival rates from 35 % to 75 % for prostate cancer patients with a pre-treatment PSA level between 10 and 20 ng/ml. Complication rates were comparable or lower when using 3D techniques. If these patients can be pre-identified as good candidates for radiotherapy, the improved local control of disease will be their ticket to a complication-free cure.

In terms of cost-effectiveness, 3D radiotherapy procedures have been analysed[22] and found to increase the cost-per-case over standard radiotherapy procedures by approximately 30 % ($14, 000 versus $11, 000). However, a successful initial course of radiotherapy is 3-fold less costly ($14,000 versus $41,000) than the treatment for recurrence, including hormone therapy. Therefore there is therefore some potential for cost avoidance attributable to better radiotherapy technology.

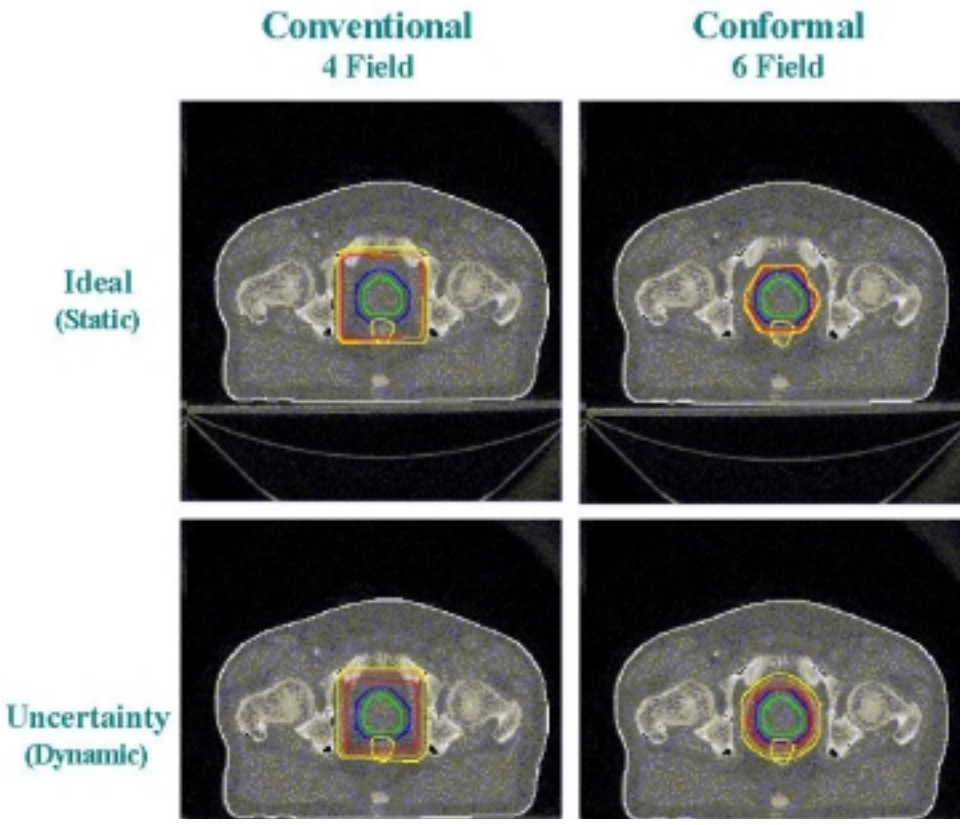


Figure 4 The impact of geometric uncertainties for treatment of the prostate with a simple 4-field box arrangements (left) and more conformal six-field arrangements (right). The upper panels show conventional isodose curves while the lower panels show the effects of organ motion and patient set-up uncertainty. The blurring of the dose into the rectum increases the risk of complications when motion is present. Images courtesy of Mr. Tim Craig, graduate student at the London Regional Cancer Centre, University of Western Ontario.

Conclusion

In summary, I have summarised ten big trends for radiotherapy on the eve of the next century. If these trends materialise it is hoped that the author's vision of the future will be applauded, retrospectively. However, if some of the trends "fizzle", it is hoped that this article may still have promoted fruitful discussion among the radiation oncology and medical physics community. There are ongoing challenges to face: a major growth in caseload, a better-informed patient who expects state-of-the-art treatment in a timely fashion, and financially-challenged health care systems undergoing restructuring. The future of 4D radiotherapy looks very challenging for the caregivers but very promising for the cancer patient.

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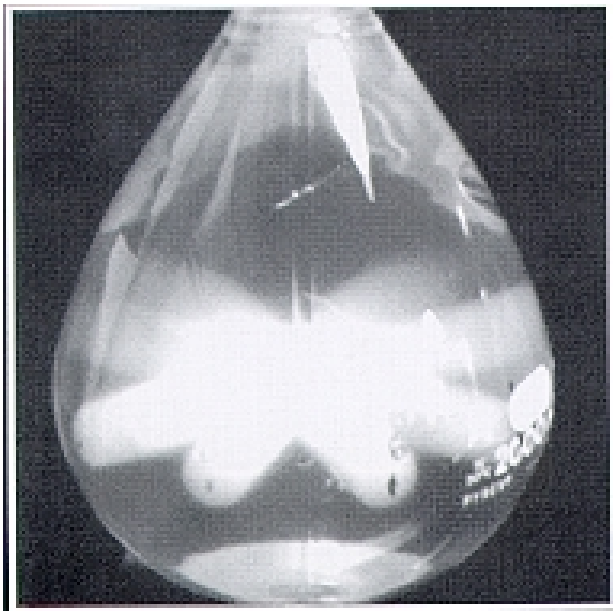

Figure 5 3D dose patterns captured "in a bottle" using polyacrylamide BANG ™ gels. The gels turn from transparent to a milky white with radiation exposure. The photograph shows a "cross-firing" pattern of several small intersecting beams. Quantitative cross-sectional images can be read-out by MRI or optical CT scans. Photo courtesy of MGS Incorporated.

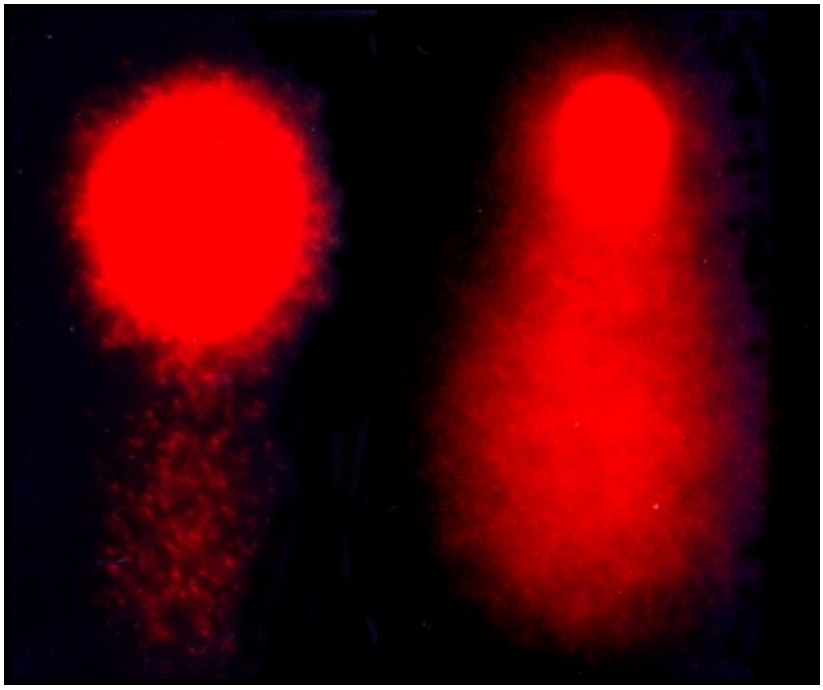

Figure 6 "Comets" showing the extent of DNA double strand breaks caused by radiation. Each panel shows the DNA from a single cell that has undergone gel eletrophoresis. After 50 Gy of radiation (right) the DNA migrates further suggesting smaller pieces of DNA than when the CHO cells have received no radiation (left). This technique can be used to measure radiosensitivity in human tumour biopsy samples[15]. Photos courtesy of Scott Karnas, graduate student at the London Regional Cancer Centre, University of Western Ontario.

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1999 Taylor Prize Winners

By Kathy Cunningham

The two winners of the 1999 J. Allyn Taylor International Prize in Medicine, **Dr. Michael Gimbrone** and **Dr. Judah Folkman**, have both made major contributions to the disciplines of vascular and tumour biology. The awards were presented on 2nd Nov. 1999 at a media conference at The John P. Robarts Research Institute. The winners each received a cheque for $10,000, a medallion and a certificate at the Institute's Annual Dinner, and presentation of the Taylor Prize.

The research accomplishments of Dr. Michael Gimbrone, Professor of Pathology, Harvard Medical School and Brigham & Women's Hospital in Boston, have furthered the understanding of the factors and components that underlie the normal structure and function of blood vessels. Dr. Gimbrone has been a pioneer in developing methods and approaches that have demonstrated that the endothelium (the interior lining of the blood vessels) is more than just a protective layer or 'plastic wrap'. Endothelial cells have many complex functions essential to health. These functions can become deranged in a predictable way in diseases such as atherosclerosis. Dr. Gimbrone discovered two pivotal molecules secreted by endothelial cells – E-selectin and VCAM-1 – which are potential new targets for novel diagnostic and therapeutic interventions in cardiovascular diseases.

Dr. Judah Folkman, Director of the Surgical Research Laboratory at Children's Hospital in Boston and Andrus Professor of Pediatric Surgery at Harvard Medical School, conceived the importance of **angiogenesis** (literally the growth of new blood vessels) to both the reestablishment of blood supply to the heart muscle and to the growth of tumours.

Dr. Folkman is one of the pre-eminent scientists of our generation. His research has not only proved the existence of angiogenesis as a biological phenomenon, but has also created a totally new therapeutic strategy to treat a variety of human diseases caused by unwanted blood vessel growth. Dr. Folkman has discovered molecules, such as endostatin, that block new vessel growth through a process called **anti-angiogenesis**. New vessel growth may promote atherosclerosis – or hardening of the arteries – the disease process that underlies the majority of heart attacks and strokes. Dr. Folkman has discovered how endostatin impedes atherosclerosis in animals, paving the way for new revolutionary treatments for human cardiovascular disease. Perhaps more importantly Dr. Folkman has discovered how endostatin and other anti-angiogenesis agents can inhibit the progression of tumours - by preventing the tumours from recruiting blood vessels that promote tumour growth. Thus, anti-angiogenesis agents cut off the blood supply and literally starve the tumours. [*Editor's note: readers can read more about Dr. Folkman in Interactions* ***45(1):*** *7-9 (1999).*]

The Taylor Prize is awarded annually to scientists who have made significant contributions to a field of basic or clinical research in one of the Robarts Research Institute's principal areas of research. Each year, a topic is selected and the international scientific community is invited to nominate candidates. A peer jury deliberates, then identifies the prize winner or winners from among the many nominees.

Mr. J. Allyn Taylor, one of the Founders of The John P. Robarts Research Institute and first Chair of its Board, is an Officer of The Order of Canada and a widely respected Canadian business leader named to the Canadian Business Hall of Fame. Mr. Taylor is an individual who, throughout his lifetime, has demonstrated a deep regard for and a passionate involvement in health care matters in Canada. The Endowment that makes the prize possible comes from the C. H. Stiller Memorial Foundation.

The award winners. Left to right: Dr Mark Posnanski, Dr. Cal Stiller, Mr. J. Allyn Taylor, Dr. Judah Folkman, and Dr. Michael Gimbone.

AECB Shuts Down the University Health Network

By Peter Munro

Note: This article was taken from publicly available documents supplied by the AECB and from discussions with Richard Cawthorn, a license assessment officer who was involved in the October 1999 inspection of the University Health Network. Individuals interested in obtaining AECB documents can contact the AECB Office of Public Information at (800) 668-5284. [REPD Report 99-A-07 (file # 15-1-12939) and REPD Report 94-A-01 (file # 15-1-1490) are the most useful.] Because of the potential employment ramifications for the individuals involved, no physicist from Princess Margaret Hospital was contacted during the generation of this article.

Between 18-22 Oct. 1999 licence assessment officers from the "Materials Regulation" and the "Radiation and Environmental Protection" Divisions of the Atomic Energy Control Board (AECB) evaluated the radiation protection program and the radiation protection training at the University Health Network. The University Health Network (UHN) is the result of the merger between the Princess Margaret Hospital, the Toronto General, and the Toronto Western Hospitals that occurred in January 1998. The assessment officers examined three aspects of the radiation protection program: the organisation of the overall program, staff qualifications, and waste control. The assessment officers found "serious items of non-compliance", which resulted in the six directives (see text box) being issued. [Note: Directives are written instructions that **require** the recipient to take corrective actions that satisfy the AECB staff.] The first two directives were issued during the site visit and the last four were issued on 4 Nov. 1999. After subsequent deliberations several other directives were issued, the most serious being the directive to cease use of all radioactive materials in all research labs of the University Health Network (see: http://www.aecb-ccea.gc.ca/news_rel/9925_e.htm). In essence all research activities that require the use of radioisotopes have ceased at the UHN.

Although the articles in the popular press (e.g., Toronto Star, 5 Nov. 1999) and rumours running through the COMP community have focussed on the radiation treatment program and activities at the Princess Margaret Hospital, the AECB's actions were the result of concerns in many areas of radiation safety program throughout all three hospitals that form the UHN. Nevertheless, the radiation therapy program of the Princess Margaret Hospital was singled out as one of the major problems in the AECB reports. In addition, according to the AECB documents, the actions of the AECB were not sudden but the result of a long history of concerns.

The University Health Network is one of the most complicated medical establishments that the AECB licenses. It holds 12 licenses for medical and research operations including an accelerator licence, nuclear medicine licences for four nuclear medicine departments, and a consolidated laboratory license for clinical labs and four research sites encompassing more than 120 labs using radioisotopes. The AECB inspection found problems with many of these licences including poor radioactive waste disposal procedures at Toronto General and Toronto Western Hospitals, essentially no radiation protection program for researchers using radioisotopes in the UHN, no coherent corporate radiation safety program for the entire UHN, a lack of effective leadership in radiation safety at the UHN, no effective reporting hierarchy within the radiation protection program, and a shortage of resources devoted to radiation safety by the UHN. Nevertheless, parts of the report focussed on perceived shortcomings by the radiation therapy department of PMH. These included lack of a radiation safety manual, lack of annual reports to the AECB, a lack of co-operation between the PMH radiation safety officer and the counterpart at the UHN, and a non-functioning PMH radiation safety committee.

Probably of most concern by the assess-

(Continued on page 17)

AECB Directives to the UHN

1. Perform and report on a thyroid bioassay of a specific worker and prohibit the worker from handling radioactive substances until authorised in writing by the AECB.
2. Shut down and lock out a research irradiator and prohibit operation of the device until an appropriately qualified person, authorised in writing by AECB, conducts tests and reports proper functioning of the safety interlock system.
3. Prohibit servicing of medical accelerators, teletherapy devices, and brachytherapy afterloaders by any person except employees of the device manufacturer or persons authorised in writing by the AECB.
4. Investigate and report on previous losses of ... radioactive brachytherapy sources.
5. Prohibit further use in, or on, human beings of radioactive substances authorised under the consolidated research license and report on all past uses.
6. Prevent futher transfers of radioactive substances to any person who is prohibited pursuant to the AECB Regulations from possessing prescribed substance and investigate and report on such past transfers.

AECB Shuts Down the UHN (Continued from page 16)

ment officers was the lack of compliance by PMH to directives that had been issued during a site visit in Feb. 1994. These directives included requirements to create an accelerator safety manual, create a training program for researchers in the use of radioisotopes, restructure the radiation safety committee, and include a PMH executive on the radiation safety committee. The accelerator safety manual was not created, the requirement for a radioisotope training program was not enforced, the radiation safety committee was restructured but then the new chair left PMH, and the PMH executive assigned to the radiation safety committee also left.

Why were some of the 1999 directives issued? During the site visit the assessment officers interviewed 28 people from all categories of staff. During one of the interviews the assessment officers were told of an incident when the individual had walked into the instrument shop during the servicing of a Calitron - one of low dose rate afterloading devices that had been developed in-house at PMH. Later this individual was surveyed with a Geiger counter and a "source" was removed from his shoe. It turned out that a dummy seed that had fallen to the floor during the servicing procedure and the individual had picked up the dummy source on his shoe when he entered the instrument shop. In another incident, an ^{192}Ir source was recovered from the dumpster behind PMH. [This apparently was not a high dose rate ^{192}Ir source but a source from a manual brachytherapy procedure.] In both of these cases no incident reports were filed with the AECB. Furthermore, interviews of the accelerator service staff revealed conflicting procedures. The service staff followed strict handling guidelines when replacing accelerator targets, but on other occasions the target was handled using bare hands.

What can COMP physicists do to prevent a repeat of the AECB actions at their institution? Good communications with the AECB is one. File an incident report immediately and investigate the incident afterwards, because the AECB is always happy to hear that an incident is a false alarm. Make sure that radiation incidents are explained carefully to all staff to prevent rumours from occurring. AECB assessment officers interview a wide cross-section of personnel - very few who have as much knowledge as physicists do about radiation safety. These staff can get erroneous ideas about what really happened and misinform the AECB. Finally, and perhaps most importantly, do not accept responsibility for radiation safety without authority - including the authority to request and receive additional resources to perform the radiation protection tasks.

The biggest repercussion (as far as medical physicists are concerned) was that Dr. Phil Leung, one of the longest serving staff in clinical physics department, was removed from his position. At the time, he was employed as a contract employee following his formal retirement in 1998. Although the University Health Network continues to honour the financial obligations of the contract and although Dr. Leung continues to teach, the abrupt termination has probably done nothing to improve the morale at PMH. This dismissal seems to be unjustified, given the nature of the problems outlined in the AECB documents. Many of the problems were institution wide and not the result of one radiation safety officer (although Dr. Leung may not have helped the situation). The UHN has found a scapegoat for the AECB actions, but the dismissal of Dr. Leung will not solve the problems (both real and perceived) identified by the AECB.

It is difficult to judge from the discussions and from the documents whether there were situations at the radiation therapy department of PMH that really could have lead to harm to staff or patients. What is clear is that the radiation therapy department at PMH was not as conscientious about filing reports with the AECB and in producing written guidelines for radiation safety as required by the terms of their licenses. This probably made it difficult for the AECB assessment officers to determine the true level of radiation safety at PMH. From the AECB response it appears that radiation therapy departments not only have to be safe – they also have to be able to prove it as well.

The University Health Network is one of the most complicated medical establishments that the AECB licenses. It holds 12 licenses for medical and research operations including an accelerator licence, nuclear medicine licences for four nuclear medicine departments, and a consolidated laboratory license for clinical labs and four research sites encompassing more than 120 labs using radioisotopes.

In Brief

More Changes at the COMP/ CCMP Office

As of 1 Nov. 1999 Barb Callaghan has replaced Lee Melnychuk as the COMP Secretarial Assistant . The mail address of the COMP/CCPM Office remains:

Post Office Box 39059
Edmonton, AB
T5B 4T8
Phone: (780) 479-1110
FAX: (780) 479-1110

Brighid's e-mail address remains bmcgarry@compusmart.ab.ca and Barb's e-mail address is bcallaghan@compusmart.ab.ca.

Brighid McGarry

Dave Rogers - 1999 AAPM Farrington Daniels Award

Once again a prominent COMP member has won a prestigious international award. Dave Rogers was awarded the Farrington Daniels Award, given for the best paper on radiation dosimetry published in Medical Physics during the previous year, for his paper entitled "A New Approach to Electron-Beam Reference Dosimetry". The award was presented during the annual meeting of the AAPM held in Nashville, TN.

Peter Munro

EGS4 Windows

For those of you interested in displaying the results of your Monte Carlo calcualtions, a new version of EGS4 Windows for displaying the results of EGS4 simulations in 3-D has been released by the Ionising Radiation Standards group of NRC. There have been many enhancements, but the major advance is that the software will now run on any X-based unix/linux system using nothing but non-proprietary packages. Another advance is that you can manipulate the displayed results in 3-D interactively. For further infor-

(Continued on page 19)

Health Economics 101

By Peter Dunscombe

Not being President of the Canadian College of Physicists in Medicine has many advantages. Chief amongst these I rated my escape from the clutches of our tenacious Interactions editor. How naïve. When it comes to our wily editor you can run but you can't hide. The presentation I made at the recent ASTRO meeting was selected for a press release and this resulted in a 50 s clip on CBC radio in Ontario. Peter Munro heard this and immediately (10:30 a.m. on a Saturday morning) fired off an e-mail requesting (commissioning?) a contribution to Interactions. I retaliated with my usual litany of excuses including workload pressures, unfavorable alignment of celestial bodies, etc, etc. However, I soon realized that my position was utterly hopeless and I capitulated. So here goes.

I've had an interest in matters economic for some time and this lead to the development of an activity costing spreadsheet based model a couple of years ago. The model is about to be published in the proceedings of a conference held in 1997. An operational analysis based on the model appeared earlier this year in the BJR (1999;72:598-603) and another paper is in print with the International Journal of Health Technology Assessment. When Rajiv Samant, a radiation oncologist, joined the Sudbury centre from Surrey, B.C., we initiated a study of the cost effectiveness of adjuvant locoregional radiotherapy in post mastectomy node positive premenopausal breast cancer patients. Costs were based on our model and effectiveness on two clinical studies, one of which is from B.C. Briefly, our conclusion was that, in the context of generally accepted medical interventions, this particular therapy would satisfy the criterion of being cost effective. I am in the process of writing the work up and hopefully it will be submitted before the end of the year.

So there you have it. Although it's not physics, I've found my foray into health economics and activity costing to be intellectually challenging and, I believe, of potential value to health policy analysts. If you are interested in a well written and succinct overview of the subject you might like to read Hayman et al.'s article in the Red Journal (IJROBP, 1996, 35, 827-841).

Canadian College of Physicists in Medicine Examination Schedule 2000

Membership Examination:

Applications due: 21 January 2000
Examination date: 15 April 2000

Fellowship Examination:

Applications due: 28 April 2000
Examination date: 20, 21 or 22 July 2000 (in Chicago)

Note: Fellowship applicants writing the membership examination should confirm their fellowship application and pay the fee within one week of receiving the membership examination results.

For further information, application kits, and membership examination study guides, contact the Registrar, Dr. Alistair Baillie, at:

Dr Alistair Baillie
The Registrar/ Le Registraire, CCPM
c/o Cancer Centre for the Southern Interior
399 Royal Avenue
Kelowna, BC, V1Y 5L3

Acoustic Cardiology

Contributed by Mike Bronskill

The world's first ultrasound imaging system, that can show physicians live images of blood perfusing the heart muscle, was presented this week to the American Heart Association's annual conference by its inventors from Sunnybrook and Women's College Health Sciences Centre.

Senior scientist in imaging research, Dr. Peter Burns and graduate student David Hope Simpson, have developed a way to use microscopic, "high-tech bubbles" and ultrasound technology to produce moving, live images of the heart. The images are able to detect flow in the smallest part of the myocardium, the muscle which may be damaged by a heart attack. This new system called, Pulse Inversion Doppler Imaging, is a revolutionary step forward in noninvasive imaging of the heart.

The method relies on injection of an ultrasound contrast agent of microscopic bubbles, smaller than red blood cells, which have recently been approved for use in Canada. Using an ultrasound scanner, the bubbles are made to emit a unique high frequency sound as they flow thorough the blood vessels that can be detected by the new system, that creates a live image of blood flow changes in tissue affected by a heart attack.

"Ultrasound imaging of the heart's structure is a very well established clinical procedure which is noninvasive, safe and relatively inexpensive", said Dr. Burns. "This technology will allow many imaging systems to be upgraded to provide additional functional information about the perfusion of its muscle: the new method is actually a new software program".

Clinical trials for Pulse Inversion Doppler Imaging are being conducted internationally. According to Sanjiv Kaul, MD, Professor of Cardiology and Director, Cardiac Imaging Center at the University of Virginia, "It's going to have tremendous impact, because it is offering totally new information".

Harald Becher MD, Professor of Cardiology at the University of Bonn in Germany, says, "Having the chance to do a study which gives us two parameters at the same time – function and perfusion – will enhance the diagnostic confidence in our testing for ischemic heart disease".

Developed under a research grant from the Medical Research Council of Canada, the new system is the result of a partnership between Sunnybrook and Women's and ATL Ultrasound, a Philips Medical Systems company. Dr. Jacques Souquet, ATL's Chief Technology Officer and Senior Vice President of Product Generation says, "With Real-time Perfusion Imaging, ATL and the echocardiography community have reached another significant milestone in ultrasound imaging of the heart. We look forward to collaborating with Sunnybrook and Women's on further breakthroughs with these exciting technologies".

For more information please contact:
Craig DuHamel, Public Affairs
Sunnybrook and Women's College Health Sciences Centre
(416) 480-6100 extension 3208
craig.duhamel@swchsc.on.ca

In Brief *(Continued from page 18)*
mation or to download the software go to http://www.irs.inms.nrc.ca/inms/irs/irs.html.

Peter Munro

Is Radiation Deficiency A Health Problem?

In the past century many diseases turned out to be due to deficiencies of essential trace elements or vitamins. For example, deficiencies of iron led to anemia. It was found that rickets in children was due to a deficiency of vitamin D. However, vitamin D is produced in the skin by UV-B in sunlight. Thus UV-B can be considered an essential trace energy.

I suggest that low dose rate radiation may also be an essential trace energy. Excellent data show that the U.S. Gulf States suffer from a deficiency of background radiation and radon. [See Natural Background Radiation and Cancer Death in Rocky Mountain and Gulf Coast States by John Jagger (Health Physics Oct. 1998 pp428-430).] The cancer death rate in the Gulf States is 25% greater and lung cancer is 45% greater than in the mountain states while the background and radon levels are much higher in the mountain states. Earlier work by Frigerio (1974) and Cohen (1995) support these results for the 48 contiguous states. I have been considering placing a 100 kg of uranium ore under my bed to supplement the low background in Florida. Perhaps radioactive waste may become a "health product."

John Cameron

Special COMP YIS Award

The COMP Executive is pleased to announce that COMP will award $250 to each COMP member* who is selected as a Finalist in the Student Paper/YIS Competition at the World Congress on Medical Physics and Biomedical Engineering in Chicago, July 23-28, 2000. The Executive would encourage COMP members to bring this opportunity to the attention of all Canadians currently enrolled as students in medical physics or who received their terminal degree within a year of the World Congress. Partial funding for travel and

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In Brief *(Continued from page 19)*
conference registration is provided to Finalists in the WC2000 Student Paper/YIS Competition by the World Congress Committee (see http://www.wc2000.org/yis_student.html).
(*Applies to those who are COMP members as of January 31, 2000. Annual dues for COMP Membership are $20 for Student and $100 for Full and a membership application can be downloaded from the COMP Web site at http://www.medphys.ca.)

Brighid Mcgarry

Another .COMpany?

Kurt Luchka is trying to establish a software company and is looking for feedback from COMP members about his current developments. If interested in evaluating his software, which generates DRR's from CT datasets – along with MLC overlays, please contact him at Luchka@telus.net.

Peter Munro

Useful Links

Masthead Imaging Corporation maintains a comprehensive list of useful links at the Web site: http://go-pips.com. The USEFUL LINKS page provides links to numerous search engines, directories and dictionaries, as well as links to academic departments, Medical Physics centres, vendors, medical and cancer sites, professional associations, journals, etc. Of special interest are the links to Physics Resources. This page is provided as a free service to the Medical Physics community, and comments and suggestions for additional categories and links are welcome.

Shlomo Shalev

So you want to be a Professional?

The Canadian Association of Physicists (CAP) has introduced a professional certification program with the official designation of P. Phys. (professional physicist). It will not be essential that physicists have the P. Phys designation in order to practice physics. However, CAP hopes (and anticipates) that the designation will become a

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Atlantic Medical Physicists Meeting

By Maria Corsten
Newfoundland Cancer Treatment and Research Foundation

The first annual meeting of the Atlantic Medical Physicists (AMP) was held September 24-25, 1999 in Saint John, NB. Physicists and dosimetrists from all four Atlantic Provinces, as well as representatives from Varian Oncology Systems, MDS Nordion and AECL attended the two-day meeting.

The physics staff at the Saint John Regional Hospital, led by Narayan Kulkarni, is to be commended for the excellent organisation of the meeting and the maritime hospitality that they extended to all the attendees throughout the weekend.

The program was a combination of discussions and presentations on current topics in medical physics with a focus on some of the unique challenges facing smaller cancer centres.

The discussions included issues such as quality assurance in 3D conformal radiation therapy, MU calculations, the role of radiation therapy physics, professional issues and the future direction of the Atlantic Medical Physics group. A separate discussion session was held for the dosimetrists to provide an opportunity for them to discuss treatment planning techniques as well as professional issues specific to dosimetrists.

Representatives from the six cancer centres in the Atlantic Provinces gave presentations at the meeting. The presentations included updates on TG-51 and DICOM RT, the implementation of new equipment and techniques (Prostate Brachytherapy, 3D treatment planning systems, CT simulators) and updates of on-going research including modeling of beam hardening, RDF of irregular electron beams and fiber optics in radiation dosimetry.

Doug Boreham, from AECL provided an interesting change in dose magnitude with his presentation on biological defense mechanisms against the effects of low doses of ionization radiation. Peter D'Amico and Daryoush Sheikh-Bagheri, from MDS Nordion, presented an update on new developments in Monte Carlo tech-

(Continued on page 21)

Atlantic Medical Physicists Meeting *(Continued from page 20)*

niques for radiation treatment planning and the new Theratron Co-60 unit. Sarah Locher from Varian Oncology Systems presented an update on Intensity Modulated Radiation Therapy and the techniques and results of centres currently using IMRT.

Special thanks to the corporate sponsors: Varian Oncology Systems and MDS Nordion.

The inaugural meeting of the Atlantic Medical Physicists was deemed to be a success by all in attendance. It provided a forum to discuss professional issues, techniques and to find out what is happening in our neighbouring cancer centres. The contacts made at this meeting will provide a basis for a cooperative effort for future challenges that may arise. The next Atlantic Medical Physicists meeting will be in Moncton, NB in 2000.

COMP Chair's Message *(Continued from page 4)*

describing the job to his successor, Stephen Pistorius, Michael pointed out that there were only three busy times of the year: the first four months, the last four months, and the middle four months. I would like to acknowledge his service to COMP and the great job he has done in formalising our budgeting and reporting processes.

May the New Year (not millennium) be kind to you and your families,

Mike Patterson

17th ANNUAL MEETING OF THE AMERICAN COLLEGE OF MEDICAL PHYSICS and Associated Workshop and Refresher Courses

The 17th Annual Meeting of the ACMP will be held May 16-20, 2000 at the Whistler Resort, British Columbia. The schedule of events is as follows:

May 16-17, 2000 — **The Annual Workshop**: *The Image-Based Treatment Process, Practical Methods for Clinical Medical Physics*

This workshop will discuss the application of advanced imaging technology for 3-dimensional analysis in medical diagnosis and treatment. It will include fundamental and advanced topics of interest to both imaging and therapy physicists in a parallel and combined session format. Specific responsibilities of the medical physicist will be highlighted throughout the workshop.

May 18-20, 2000 — **ACMP Annual Meeting**. Program will include:

Cardiac Imaging and Treatment (May 18)

Developing Budgets in Medical Physics

Annual Mammography Symposium (May 19)

May 18-19, 2000 — Refresher Courses in Diagnostic and Therapy Physics

CAMPEP credit is being applied for. Further information regarding this program will be available soon on the ACMP webpage: **www.ACMP.org**

In Brief *(Continued from page 20)*

de facto professional standard held in high regard by physicists. The right to use the designation will be granted by way of license from CAP, which will own the designation via a federal trademark. Individuals who do not receive the right from CAP will not be able to use the designation, and CAP has the right to pursue legal action for its unauthorised use. There are several costs related to holding the P. Phys. designation including a $100.00 application fee, a $50.00 examination fee, and a $50.00 annual fee. In addition, one must be a member of CAP. The COMP executive has made a formal request to CAP to see if COMP membership could be substituted for CAP membership. For more information please see http://www.cap.ca/trademark.htm.

Peter Munro

Illegal Organisation?

Have you ever wondered about the inner workings of COMP? For many years COMP members have been approving changes in the Bylaws of the organisation. However, one of the requirements of maintaining our status as a non-profit organisation is the reporting of all Bylaw changes to the Corporations Directorate of Industry Canada, which is part of the Department of Consumer and Corporate Affairs. [For more information about the process see http://strategis.ic.gc.ca/SSG/cs00009e.html.] Unfortunately, this reporting has not been done in the past, making our current executive activities contrary to the laws that govern our non-profit corporation. Fortunately, Curtis Caldwell, the current Secretary of COMP recognised our reporting omission and submitted a comprehensive set of Bylaw changes to the Corporation Directorate in early November. And on the 17th Nov. 1999 all the previous Bylaw changes were approved by the Directorate. So COMP members (or at least its executive) no longer have to fear the long arm of the law!

Peter Munro

NRC Fee Increase

In early January 2000, fees charged by NRC for calibration services will increase

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Organisational Structure of the COMP/CCPM Partnership

By P.C. Johns and P.B. Dunscombe

The CCPM came into being in 1979 and the COMP in 1989. The COMP is the direct descendant of an organization formed in 1955 which later became the DMBP of the CAP (e.g, see Ref. 1). During the last ten years, there has been some evolution of the working relationship between the COMP and the CCPM. This article summarizes the current arrangements.

The two organisations have always had a close relationship, and this is mandated by their Bylaws. In particular, the COMP Bylaws stipulate that one of the objectives of the COMP is to promote the recognition of the importance of certification by the CCPM and to encourage eligible COMP members to apply for certification (COMP Bylaws, Article II). The CCPM President is a full voting member of the COMP Executive (COMP Bylaws, Article IV). The annual conference and educational symposium are to be a joint effort (COMP Bylaws, Article V), and the CCPM AGM is to take place at that time (CCPM Bylaws, Article V). The CCPM is to be guaranteed financial support to maintain its activities relating to certification and continuing education (COMP Bylaws, Article VIII). And in the unlikely event of the termination of either organisation, the assets are to be transferred to the other (COMP Bylaw No. 2; CCPM Bylaws, Article IX).

From the birth of the COMP until 1997 the two societies maintained separate financial accounts, although only one fee has been collected from the members by their national organisations. The dues paid by medical physicists who were only in the COMP were retained by the COMP, while the dues paid by those in both organisations were divided 70:30 (and later 60:40) between the COMP and the CCPM, respectively. While this arrangement looked nice on paper, in practice it was found to lead to squabbling between the organisations. With so many of the activities being joint (such as the Canadian Medical Physics Newsletter, the Secretariat, and the conference), there was an attraction to start to divide the revenue and cost of each of these activities between the organisations as well. This only lead to debates on micro-accounting. At the November 1997 mid-year business meetings it was decided that a new, simpler, working relationship was needed. The model that was adopted at those meetings was implemented with the 1998 fiscal year and has proven to be a success for both organisations.

The accompanying chart shows the reporting structure of the committees and external liaisons of the two organisations. For many years, the COMP Executive and the CCPM Board have met to discuss common business. It is now explicit in the committee structure that Conference activities and Communications (the Newsletter, web site, etc). are overseen by the joint entity of the COMP Executive plus the CCPM Board. Furthermore, in 1997 it was agreed that the Radiation Regulations Committee and the Professional Affairs Committee would report jointly to both organisations. It was also agreed that the chairs of these latter two committees will hold MCCPM or FCCPM certification. (There are no constraints on the other members of these two committees). Furthermore, commencing with the 1998 fiscal year a joint Finance Committee has overseen the revenue and expenses of the two organisations as a whole. The joint Finance Committee consists of the COMP Chair, CCPM President, COMP Chair-Elect, CCPM Vice-President, COMP Treasurer, and CCPM Secretary-Treasurer. Indeed, the approach of one overall treasury was in the original Trinity College Accord, written during the negotiations between the DMBP and the CCPM on the founding of the COMP (Ref. 2).

The CCPM is solely responsible for the professional certification of medical physicists. Under the Terms of Reference of the Finance Committee, this activity is intended to be self-supporting. The CCPM is also involved in accreditation of educational programs by the CMA, and is in the process of becoming a sponsoring organisation of CAMPEP, which accredits medical physics graduate educational programs and residency programs. The COMP maintains several external links, including the IOMP and the CAP. It is a member of the Canadian Consortium for Research, and of the Canadian Radiation & Imaging Societies in Medicine. These coalitions are advocates for research funding and health care funding, respectively. Furthermore, the COMP has a Corporate Membership category and actively solicits its corporate participation in the society, especially in the conferences and in the Newsletter. The COMP is also the home for student members.

Roughly, the organisation chart reflects three categories of activity: certification activities, which fall under the purview of the CCPM; scientific activities, advocacy with funding agencies, and corporate relations, under the COMP; and conference issues, professional affairs, and communications with regulatory bodies, which both organisations are active in.

As one example of how the structure has helped unify our efforts, consider the area of radiation regulations. Prior to 1997 the Radiation Regulations Committee reported to COMP. However, the Ontario HARP Commission requested representatives to its various advisory committees from the CCPM. Obviously the subject material overlaps: e.g., in the last two years the Radiation Regulations Committee has been dealing with the AECB's interest in QA standards for radiotherapy, while such standards have just been implemented in Ontario under HARP. The Ontario standards might serve as a template for the national standards which the AECB will enable. Obviously the physicists dealing with these two regulatory agencies must consult each other. Under the new structure, the HARP reps report to the joint COMP/CCPM Radiation Regulations Committee.

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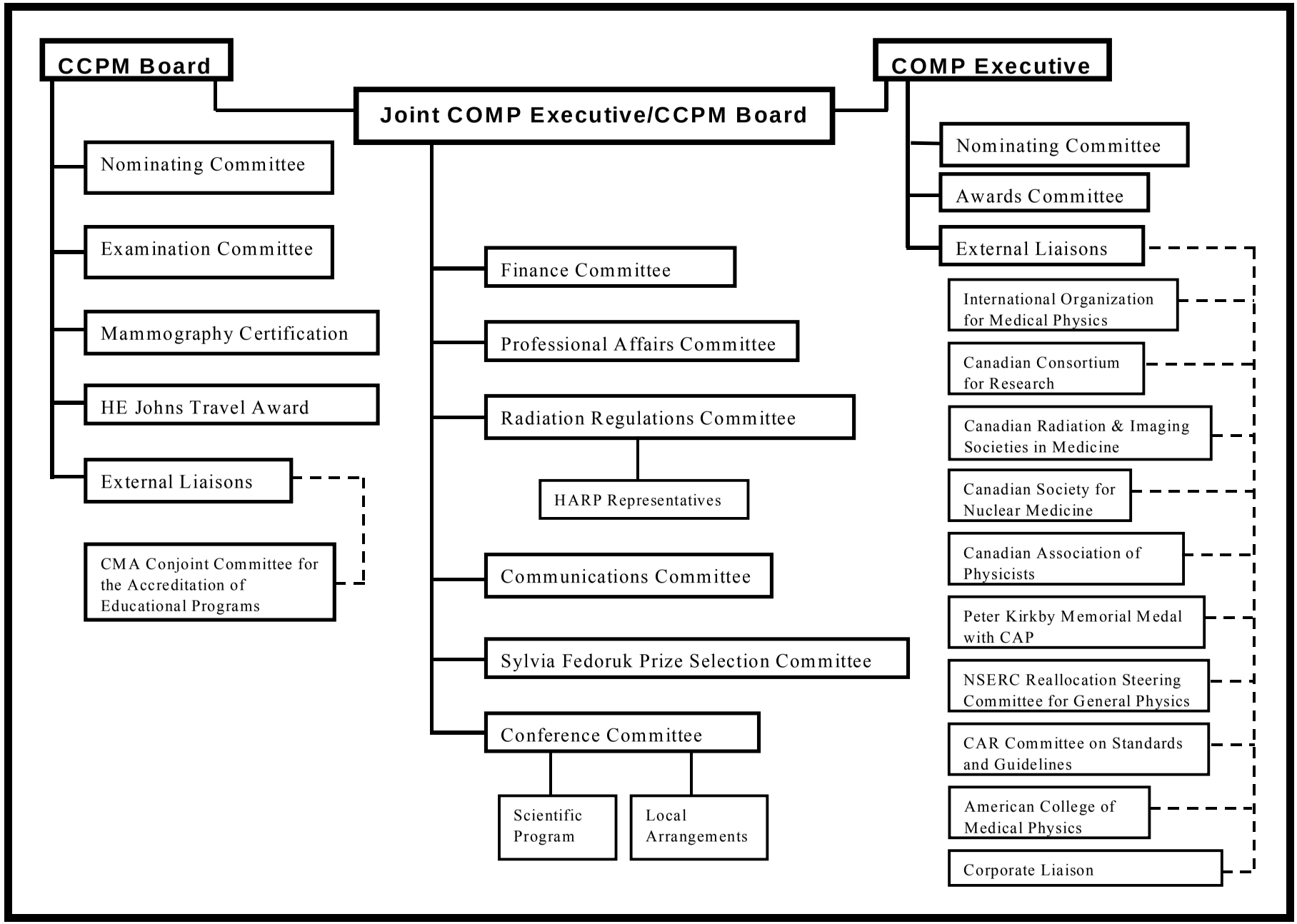
CANADIAN MEDICAL PHYSICS ORGANISATIONS
COMMITTEE STRUCTURE as of 20 November 1999



Registration and Abstract Submission Instructions for the Chicago 2000 World Congress.

The Registration Process
Meeting Registration is REQUIRED prior to Abstract Submission although the registrant may defer payment of Registration Fees until notified of paper disposition on April 3, 2000. Meeting Registration will be available via the Internet only. Once you register, you will be given a "Registration ID." This ID will be required during the abstract submission process.

Register and pay in full by May 15, 2000 in order to receive discounted registration fees. Deadline for advance meeting registration is June 19, 2000. After that time, only on-site registration will be available.

Electronic Abstract Submission System Information
Abstracts can be submitted between November 1, 1999 and the closing date of January 14, 2000.Abstracts are submitted electronically by accessing the World Congress web page at http://www.wc2000.org.

Each Registrant may submit up to two abstracts for consideration for the Chicago 2000 World Congress Meeting. An individual may **present** only two Oral Presentations at the meeting, although the individual's name may **appear** on more than two abstracts. Before submitting abstracts, the Author must register for the meeting. Payment for registration may be deferred until notification of abstract acceptance at which time, payment in full, or a $50 non-refundable down payment toward registration, is required. Abstract Submission for the Chicago 2000 World Congress is a two part submission, a web based portion where you will fill in information about an abstract and the authors submitting it, and an e-mail based portion where the documents that comprise the 250 word abstract and a 750k max file size short paper will actually be e-mailed to the server.

Before You Begin
Here is a list of items needed prior to beginning the web based portion of abstract submission:

Your unique conference registration ID for login. List of Authors first and last names. Each Authors Institution Name, City, State/Provice/Country. Abstract Title. Corresponding Author contact information. The Presenting Mode you are requesting. The Track you are submitting to.

Here is a list of items needed prior to beginning the e-mail based portion of abstract submission:

A 250 word maximum abstract containing text, formulas and symbols (created using the "Symbol" font only), composed in Microsoft Word, Corel WordPerfect or ASCII Text. There is to be no title or author information, and no graphs, figures, tables, images or multimedia elements in this document. For details on including formulas, see Document Submission Rules below. A statement within your abstract disclosing any "Conflict of Interest" that may exist.

An optional 750k max file size Short Paper composed in Microsoft Word, Corel WordPerfect or ASCII Text. Short Papers should contain Title and Author information. Short Papers may contain graphs, figures, tables and images. For details on including formulas, see Document Submission Rules below.

Once you have logged into the system, you are given the following options:

Submit New Abstract - will begin a new submission process. Check on the Status of a Previously Submitted Abstract - will allow you to enter your Abstract ID Number to view the Status of your submission as well as your converted documents. If you see a problem with your converted document, you may reset your document and resubmit it. Your submission will not be considered complete unless you approve your converted submission by clicking the "I approve conversion" checkbox.

Abstract Submission - Step 1
Enter the title of the abstract to be submitted, then click next.

Use upper and lower case when entering title. DO NOT use all upper case. DO NOT use all lower case. To enter superscript text put the following tags around the text to be superscripted:

^{text}

To enter subscript text put the following tags around the text to be subscripted:

_{text}

Abstract Submission - Step 2
Enter the authors for this abstract.

The system requires a phone number. This is used to ensure that authors are correctly credited for each paper they are listed on in the author index. Use proper capitalization when entering author names. DO NOT use all upper case. DO NOT use all lower case. Enter the names in the order they are to appear when published. Use arrow buttons at left of names to change order. Check spelling as you go; if a name is misspelled, the misspelled name must first be removed then the correct spelling added. Click the "ADD" button after each author's name is entered.

Abstract Submission - Step 3
Corresponding Author Contact Information, Author/Institution and Requested Presenting Mode are entered on this screen

The following fields are required:

First Name Last Name Phone E-mail Street Adress City/State/Zip Country By-Line (see Author/Institution Line instructions below) Requested Presenting Mode Subject Category

Author/Institution Line
Use the following format when all authors from same institution:

T Webster, M Warden, L Salliman, A Geyser, Memorial Sloan Kettering, New York, New York

Use the following format when Authors are from multiple institutions:

Note that this code

T Webster¹, M Warden¹, L Salliman¹, A Geyser², (1) Memorial Sloan Kettering, New York, New York, (2)University of MD, College Park

(Continued on page 25)

Produces this output:

T Webster1, M Warden1, L Salliman1, A Geyser2, (1)Memorial Sloan Kettering, New York, New York, (2)University of MD, College Park

Conflict of Interest Statement
Rules Regarding Conflict of Interest

Authors of scientific oral or poster presentations who have entered into a financial relationship with sponsoring companies or organizations about whose product or services they are reporting must disclose this information. If such a financial arrangement is known to the authors, a disclosure statement must be placed at the end of the abstract. For example: "The research described in this abstract was supported by a grant from ____ corporation." It is recognized that much scientific research is supported by organizations which have a commercial interest in the results of the research. This policy is not intended to discourage such support, or restrict the dissemination of the research. It is the intent of this policy to require authors of scientific presentations to disclose the sources of their support, when those sources have a direct interest in the research. This is to permit members of the audience to form their own judgements about the research with the full disclosure of the facts.

Document Submission Rules
Rules Regarding Submission of Documents

ABSTRACTS: An Abstract consists of 250 words or less of text, formulas and symbols (created using the "Symbol" font only), composed in Microsoft Word, Corel WordPerfect or ASCII Text. Abstracts that exceed 250 words will be rejected. There is to be no title or author information, and no graphs, figures, tables, images or multimedia elements in this document. Abstracts containing graphs, figures, tables or images or multimedia elements will be rejected. Abstracts must be submitted as an e-mail ATTACHMENT. Do not type your Abstract text into the body of the e-mail. File ATTACHMENTS must be in Microsoft Word, Corel WordPerfect, or ASCII Text format. The recommended format, to ensure the highest level of compatibility, is Microsoft Word 97. For best results, Mac WordPerfect users should save documents as MS Word 4, 5, or 6 prior to submission.

Special Note to WordPerfect 8 and higher users! Corel WordPerfect 8 and higher includes two equation editors. The WordPerfect 5.1-7 Equation Editor must be used when creating equations. To use the WordPerfect 5.1-7 Equation Editor, click Tools / Settings / Environment / Graphics / WordPerfect 5.1-7 Equation Editor.

Do not include the names of authors in the Abstract text file. If submitting as a Young Investigator, Lisa Rose Sullivan at Chicago 2000 HQ [lrose@wc2000.org] must receive an e-mail letter of eligibility from the author's sponsor identifying the institution by March 10. All e-mails are subject to verification by Chicago 2000 HQ.

Authors must view their converted documents and approve them for the submission to be marked complete.

OPTIONAL SHORT PAPERS: Short Papers may be submitted as Microsoft Word, Corel WordPerfect, ASCII Text format, or a PDF file with embedded multimedia. Short Papers must be submitted as an e-mail ATTACHMENT. Do not type your Short Paper into the body of the e-mail. If submitting a PDF file, the word "PDF" must be put in the body of the e-mail.

If not submitting a PDF file, ATTACHMENTS must be in Microsoft Word, Corel WordPerfect, or ASCII Text format. The recommended format, to ensure the highest level of compatibility, is Microsoft Word 97. For best results, Mac WordPerfect users should save documents as MS Word 4, 5, or 6 prior to submission.

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Short Papers may contain graphs, figures, tables and images. If the submission includes multimedia, the Short Paper must be submitted in PDF format with the multimedia embedded.

There is a four page limit on Short Papers. Only the first four pages of the document will be accepted; any additional information will be discarded. Authors must view their converted documents and approve them for the submission to be marked complete.

POWERPOINT PRESENTATIONS:
PowerPoint is not accepted by the system natively, however, a PowerPoint file may be embeded into a Word document in the following way:

Open PowerPoint, and then open the presentation to be exported to Word. On the File menu, point to Send To, and then click Microsoft Word. In the Write-Up dialog box, select the desired layout. Existing notes may be positioned next to or below the slides, include blank lines for additional notes, or a simple outline of the presentation text without slide images may be exported. To insert the slides as embedded objects, click Paste.

Powerpoint tends to be a large file format, please ensure that the file is less than 750k or it will automatically be rejected.

Alternatively, create a PDF from the Presentation and submit as PDF.

Document Status Screen
This shows the status of the documents. By looking at this, the author should be able to see if the system has received an Abstract document and/or Short Paper.

If the documents were received without any problems, then there will be a link to the Adobe Acrobat PDF file that was created. Click on the linked file name to view the document and ensure there were no errors introduced in conversion. Authors must view their converted documents and log in to the status screen to approve them before the submission will be marked complete.

NOTE: If you have previously submitted a document and would like to resubmit it for any reason, you may press the "Reset" button associated with that document below. This will 1) notify the system that the documents will be resubmitted and 2) all references to previously submitted documents will be removed.

After resetting a document, resubmit the new document through the same e-mail submission process. Rules for submission are here. You will only have the option to reset a submitted document if it has been received as noted above. Please be completely sure that you wish to resubmit a document before following this procedure.

2000 Sylvia Fedoruk Prize in Medical Physics

The Saskatchewan Cancer Agency is pleased to sponsor a competition for the 2000 Sylvia Fedoruk Prize in Medical Physics. This award is offered annually to honour the distinguished career of Sylvia Fedoruk, former Lieutenant-Governor of Saskatchewan and previously physicist at the Saskatoon Cancer Centre.

The prize will comprise a cash award of five hundred dollars ($500), an engraved plaque and travel expenses to enable the winner to attend the annual meeting of the Canadian Organization of Medical Physicists (COMP) and the Canadian College of Physicists in Medicine (CCPM) which will be held in conjunction with the World Congress of Medical Physics and Biomedical Engineering, July 23-28, 2000 in Chicago.

The 2000 Prize will be awarded for the best paper on a subject falling within the field of medical physics, relating to work carried out wholly or mainly within a Canadian institution and published during the 1999 calendar year. The selection will be made by a panel of judges appointed by COMP.

Papers published in *Physics in Medicine and Biology* and *Medical Physics* which conform to the conditions of the preceding paragraph will automatically be entered in the competition and no further action by the author(s) is required. All other papers must be submitted individually. Four (4) copies of each paper being entered must be sent to:

The Chief Executive Officer
Saskatchewan Cancer Agency
2631 28th Avenue, Suite 400
Regina, SK, S4S 6X3
Tel: (306) 585-1831
Fax: (306) 584-2733

Each paper must be clearly marked: "Entry for 2000 Sylvia Fedoruk Prize" and must reach the Saskatchewan Cancer Agency no later than **Tuesday, February 15, 2000**.

The award winners from the last five years were:

R.G. Kelly, K.J. Jordan, and J.J. Battista, "Optical CT reconstruction of 3D dose distributions using the ferrous-benzoic-xylenol (FBX) gel dosimeter", *Medical Physics* **25**, 1741-1750 (1999).

C.E. Zankowski and E.B. Podgorsak, "Calibration of photon and electron beams with an extrapolation chamber", *Medical Physics* **24**, 497-503 (1997).

C.J. Henri and T. M. Peters, "Three-Dimensional Reconstruction of Vascular Trees. Theory and Methodology", *Medical Physics* **23**, 197-204 (1996).

W. Zhao and J. A. Rowlands, "X-ray Imaging using Amorphous Selenium: Feasibility of a Flat Panel Self-Scanned Detector for Digital Radiology", *Medical Physics* **22**, 1595-1604 (1995).

R.M. Henkelman, G. J. Stanisz, J. K. Kim, and M. J. Bronskill, "Anisotropy of NMR Properties of Tissues", *Magnetic Resonance in Medicine* **32**, 592-601 (1994).

COMP OCPM

CANADIAN ORGANIZATION OF MEDICAL PHYSICISTS

ORGANISATION CANADIENNE DES PHYSICIENS MÉDICAUX

CALL FOR NOMINATIONS

Nominations for Councillor for Communications*

(Term: From Annual General Meeting of July 2000 until AGM in 2003)

and

Nominations for Chair-Elect

(Term: From Annual General Meeting of July 2000 until AGM in 2002; progresses to Chair in 2002, to Past-Chair in 2004; completion in 2006)

Nominations must be signed by two sponsoring members and by the nominee who by his/her signature agrees to accept the nomination.

Please send nominations to:

APPEL POUR MISES EN CANDIDATURE

Candidature comme conseiller des communications**

(Terme: De la réunion générale annuelle de juillet 2000 jusqu'à la RGA de 2003)

et

Candidature comme vice-président(e)

(Terme: De la réunion générale annuelle de juillet 2000 jusqu'à la RGA de 2002, devient président(e) en 2002, ancien (ne) président(e) en 2004, fin en 2006)

La mise en candidature doit être signée par deux membres actifs et par le ou la candidat(e) qui indique par sa signature qu'il ou elle accepte la mise en candidature.

Envoyez vos mises en candidature à:

Dr. Paul C. Johns
COMP Past-Chair
Department of Physics
Carleton University
1125 Colonel By Drive
Ottawa, Ont. K1S 5B6
Tel: (613) 520-2600 x4317
Fax: (613) 520-4061
E-mail: johns@physics.carleton.ca

Nominations must be received by April 1, 2000.

An election by mail ballot will be conducted in the spring. The results will be reported at the Annual General Meeting in Chicago in July 2000.

*** Note**: A Bylaw change is proposed to rename the post of Councillor for the Newsletter to Councillor for Communications. This reflects the expanded mandate of the Communications Committee. (See proposed Bylaw Changes elsewhere in this issue of Interactions).

Les mises en candidature doivent être reçues avant le 1er avril 2000.

L'élection se fera par la poste au printemps. Les résultats seront rapportés à la réunion générale annuelle à Chicago en juillet 2000.

**** Avis**: Il est proposé de modifier les règlements afin de changer le titre de "conseiller du bulletin de nouvelles" à "conseiller des communications". Ceci pour mieux refléter l'expansion du mandat du comité de communications. (Voir les changements proposés aux règlements dans cette édition d'Interactions).

HAROLD JOHNS TRAVEL AWARD

The Board of the Canadian College of Physicists in Medicine is pleased to honour the Founding President of the College by means of the Harold Johns Travel Award for Young Investigators. This award, which is in the amount of $1500, is made to a College member under the age of 35 who became a member within the previous three years. The award is intended to assist the individual to extend his or her knowledge by traveling to another centre or institution with the intent of gaining further experience in his or her chosen field, or, alternately, to embark on a new field of endeavour in medical physics.

Further information can be obtained from:

BOURSE de VOYAGE HAROLD JOHNS

Le Conseil du Collège Canadien des Physiciens en Médecine est heureux d'honorer son président fondateur en offrant aux jeunes chercheurs la bourse Harold Johns. Cette bourse, d'une valeur de $1500, est éligible aux membres du Collège agés de moins de 35 ans at qui sont membres depuis moins de trois an. La bourse a pour but d'aider le récipiendaire à parfaire ses connaissances dans son domaine ou à démarrer dans un nouveau champ d'activités reliées à la physique médicale, en lui permettant de voyager vers un autre centre spécialisé.

Les demandes seront addressées à:

The Registrar / Le Resistraire
CCPM
c/o Cancer Centre for the Southern Interior
399 Royal Avenue
Kelowna, BC, V1Y 5L3

The deadline for applications for the next award is **May 1, 2000**. The award will be announced at the 1999 CCPM Annual General Meeting in Sherbrooke.

La date limite pour les demandes du prochain concours est le **1er mai 2000**. Le récipiendaire de la bourse sera annoncé à la rencontre annuelle de 1999 du CCPM à Sherbrooke

Past recipients:

Récipiendaire anterieur:

1990 Dr. L. John Schreiner, Montreal
1991 Ms. Moira Lumley, Kingston
1992 Dr. Donald Robinson, Edmonton
1993 Dr. Yunping Zhu, Toronto
1994 Dr. Brendan McClean, Edmonton
1995 Dr. George Mawko, Halifax
1996 M. Alain Gauvin, Montreal
1997 Dr. Katherina Sixel, Toronto
1998 Mr. Horacio Patrocinio, Montreal
1999 Mr. Craig Beckett, Regina

Members of the COMP and/or CCPM can make a donation to fund by volunteering to increase their 2000 membership dues.

Les membres du COMP et\ou OCPM peuvent faire un don à la cotisation de 2000 un montant additionel de leur choix.

Proposed COMP ByLaw Changes

1. ARTICLE IV: Officers

A) OFFICERS OF THE EXECUTIVE

6) Now reads: Councillor (for the Newsletter)

Change to: Councillor (for Communications)

B) ELECTION OF OFFICERS

2) Now reads (in part): Councillor (for the Newsletter)

Change to: Councillor (for Communications)

C) DUTIES OF OFFICERS

Now reads (in part): The Councillor (for the Newsletter) is mainly responsible for the newsletter.

Change to: The Councillor (for Communications) chairs the Communications Committee and is ultimately responsible for the newsletter, website, publications, and all other matters falling within the terms of reference of the Communications Committee.

Note: The terms of reference of the Communications Committee must also be changed so the phrase "COMP Councillor for the Newsletter" becomes "COMP Councillor for Communications".

Rationale: This change reflects the new and expanded mandate of the Communications Committee and the increasingly important role of communications within the organisation.

2. ARTICLE V: Meeting of the Members

E) Now reads: The QUORUM of the annual general meeting is 20% of full members.

Change to: The QUORUM of the annual general meeting is 10% of full members.

Rationale: The 20% quorum has barely been achieved at recent annual general meetings and may be more difficult to meet in the future.

3. ARTICLE V: Meeting of the Members

Add: **J)** The rules contained in the Modern Edition of *Robert's Rules of Order* shall govern the COMP in all cases where they are not inconsistent with these bylaws and any special rules of order the COMP may adopt.

Rationale: It is common for organisations (e.g. CCPM) to adopt these rules of parliamentary procedure.

In Brief *(Continued from page 21)*

by about 10% across the board. Since the last fee increase was implemented in 1994, this represents an increase less than 2% per annum. For calibration in terms of air kerma using low and medium energy x-rays, the fee for the first x-ray quality will be $950 and for subsequent qualities, it will be $220. For calibration in terms of absorbed dose to water using cobalt-60, the fee will be $1030. The cost for an air kerma calibration using cobalt-60 is the same as for calibration in terms of absorbed dose to water. Fees for those calibration requests already in the queue will be charged the "old" rate.

Ken Shortt

Do MR Imagers Have More Fun?

For those of you who have ever wondered what causes those regular thumping noises when MR images are acquired, a possible answer has been unveiled in a recent issue of the British Medical Journal. Four researchers have just published a study examining the genitalia of couples undergoing sexual intercourse while in the bore of an MR imager (see http://www.bmj.com – "Magnetic resonance imaging of male and female genitals during coitus and female sexual arousal" W.W. Schultz, P. van Andel, I. Sabelis, and E. Mooyaart, BMJ 1999; 319: 1596-1600.) According to the study the penis has the shape of a boomerang during sexual intercourse and the size of the uterus does not increase during sexual arousal. No news on whether further "penetrating" research is being planned at Canadian institutions.

Peter Munro

Nominations to the Board of the Canadian College of Physicists in Medicine

As immediate Past-President of the College, I become a member of the Nominating Committee whose next task is to fill my position on the Board when my second term is complete at the AGM in Chicago, 2000. Tradition in recent years has seen the Nominating Committee present the names of nominees for first or second terms to the AGM for approval. Nominations from the floor and competitive ballots have not been seen by the Board as optimum or appropriate methods for identifying and selecting the best prospective Board members.

To assist the Nominating Committee in its task, I am now soliciting nominations for consideration by the Committee. In making its final decision the Nominating Committee does consider discipline, geographic and other factors in order to arrive at a balance in Board membership which reflects the distribution of College membership.

Please contact me with the names of suitable candidates (you can nominate yourself) by 31st March, 2000. You don't need to get the approval of the candidate you nominate although you may wish to. Whoever is selected for nomination will be contacted by a member of the Committee to ensure that they accept the nomination.

Peter B. Dunscombe
peter.dunscombe@nercc.on.ca

Organisational Structure: COMP/CCPM (Continued from page 22)

Our organisations are relatively small. There are 158 certified physicists in the CCPM. The COMP consists of these physicists plus another 139 for a total of 297 Full Members. There are an additional 105 members of the COMP in other categories: student, associate, emeritus, retired, and corporate. The current structure allows us to maintain both a general scientific and professional society (COMP) and a certifying body (CCPM) as do all of the major self-regulating professions. The overlap of committees in the current working arrangement and close co-operation allow us efficiency in our tasks on behalf of both certified and non-certified medical physicists in Canada.

The structure can and will continue to evolve. For example, the Canadian Council on Health Services Accreditation has solicited input from medical physicists representing both organisations, and we are now deciding how this should be handled efficiently.

We plan to add the organisation chart and the Terms of Reference of the committees to the Directory at its next printing.

1. J.E. Aldrich, The Canadian Organization of Medical Physicists, pp. 327-331 in J. E. Aldrich and B.C. Lentle, eds., *A New Kind of Ray*, Canadian Assoc. of Radiologists, 1995.
2. Canadian Medical Physics Newsletter, pp. 2-3, also pp. 4-6, p. 7, June 1988.

From the Editor *(Continued from page 56)*

advertising, Corporate Members page), news stories and articles (which would require two people from different backgrounds – e.g., therapy and imaging), layout and production, and perhaps an Editor in Chief – to take the credit for the efforts of the others. The key is to find people who are enthusiastic about Interactions and who are willing to make an effort to see it continue. We are a small organisation with many diverse interests, so we need a mechanism to encourage communication. This may be your chance to do something that may make a difference. Please do not let me down!

DON DAWSON RETIRES

By John Taylor

On November 30, 1999 the London Regional Cancer Centre marked the retirement of Dr. Donald J. Dawson, who wrapped up what must be, after 34.5 years, one of the longest continuous tenures in a Canadian Medical Physics department. Dr. Dawson first joined the Centre in 1965 with a Ph.D. in Nuclear Physics from the University of Toronto, and since then he has been actively involved in the practice of radiation therapy physics from radium and betatrons to MLC's and IMRT. He served as Head of Clinical Physics and Radiation Safety Officer from 1986 to 1995, and has held an academic appointment at the University of Western Ontario since 1966. In his teaching capacity, he has contributed to the training of many of today's leading Radiation Oncologists and Medical Physicists, such as Jake Van Dyk and Jerry Battista. In recent years he has concentrated on implementing comprehensive Quality Assurance programs in Radiation Therapy, and on refinements in radiation bunker design, which have allowed the heavy neutron shielding doors to be removed from the London treatment bunkers.

Dr. Dawson has now begun a new career as an independent consultant, initially on contract with Cancer Care Ontario to design radiation treatment bunkers for new Ontario cancer centres. His steadying influence at the London Regional Cancer Centre has been greatly appreciated over the years by all his colleagues, and we all wish him well in his future endeavours.

Graduate Theses 1998

By Darcy Mason

COMP has a tradition of publishing thesis titles and abstracts of medical physics work from Canadian institutions. My appreciation goes to John Schreiner, who preceded me in the task of collecting these. As our field expands, the communications committee was looking to streamline the process of collecting the ever-increasing number of thesis abstracts. After some unproductive leads, it turns out that the abstracts are listed in the Dissertations Abstracts database (D.A.), which now has on-line web searching capability. We made an arrangement with Bell and Howell to use their service to do the collecting for us, as long as appropriate references to their company and web site were made. This has simplified the process tremendously, but has come with some limitations. For example, the abstract comes in only one language. In the past both French and English version were typically listed for abstracts originating within Quebec. Also, the year listed in D.A. is not always the same as the institution states. And, some abstracts have been shortened - this is indicated when it has happened.

In Dissertation Abstracts, the theses are categorized by institution and subject code (one or more), not by university department. Therefore, some judgment is needed to decide which are really "medical physics" and which are primarily Biology or Chemistry or Engineering (or Computer Science even), since many list these codes as well. I have tried to eliminate only ones that clearly had their focus in these other areas. However, this could have removed some that were in fact awarded through a Medical Biophysics department, for example. Conversely, I was able to search broadly and turn up many titles that will be of interest to the medical physics community, even if the degree was from another discipline.

The subjects I used for the search were "Biophysics, Medical", "Biophysics, General", "Physics, Radiation", "Physics, General", "Health Sciences, Oncology", and "Health Sciences, Radiology". The first one, "Biophysics, Medical", produced a set which were all on target. With the remaining subject codes, I had to filter the titles, especially with the last two. I don't know how these subject codes are assigned, but I suggest you try to include one or more of the first three in the coding used for your future graduates.

I realize that many abstracts for 1998 are missing from the D.A. database. In particular I was aware that McGill, McMaster, and Toronto were underrepresented. I managed to get some of the Toronto ones by other means before the publication deadline. I apologize for any missing, and ask that you please let me know of any so they can be included in a future edition of Interactions. Also, if your students can send me (dmason@bccancer.bc.ca) electronic copies of their abstracts when completed, that would help to ensure that none are missed.

Finally, a plug for the web site: all of these abstracts, and the ones currently missing, will be kept indefinitely on the web site so you will be able to see the complete collection there.

For more information on the abstracts or to order a copy of a dissertation, contact Bell & Howell Information and Learning Company (formerly UMI), 300 North Zeeb Road, Ann Arbor, MI 48106-1346 USA. Telephone (734) 761-7400; E-mail: info@bellhowell.infolearning.com; Web-page: www.bellhowell.infolearning.com.

As indicated earlier, some abstracts were not available in time for this publication. In future, a complete list will be available at www.medphys.ca.

Carleton University

Investigation Of Adaptive Response In Human Tumour And Normal Cell Lines With Varying Radiosensitivity

Boyden, Sheri, MSc; Advisor: Raaphorst, Peter

The existence of cellular radioprotective mechanisms that can be upregulated in response to exposure to small doses of ionizing radiation has developed into an important area of investigation. There appear to be two ways these 'induced' mechanisms operate. They either influence the response of cells to single doses so that small acute radiation exposures are more effective per unit dose at causing cell lethality than larger exposures above a threshold where the induced radioprotection is triggered, or they protect the cells against a subsequent exposure to radiation that may be substantially larger than the initial priming dose given several hours earlier. This study investigates the latter mechanism which is termed 'adaptive response'. 6 cell lines were studied to determine if the adaptive response is dependent on the type of cell or on the radiosensitivity of the cell. Cells were primed with a small priming dose of X-radiation 6 h before the challenge dose of X-radiation. A range of priming doses, from 0.2-4Gy, was investigated as well as various challenge doses (1-8 Gy). Of the 6 cell lines studied, only the T47D breast carcinoma cells showed an adaptive response when primed prior to the challenge dose. The results from this study give no indication that radioadaptability is related to the type of cell, or to the cell's intrinsic radiosensitivity. The adaptive response was also not found to be related to the cell's ability to repair sub-lethal or potentially lethal radiation damage.

Hydroxyl Radical Scavengers And Antioxidants In Radiation Protection (Melatonin)

Lenton, Kevin James, PhD; Adviser: Greenstock, C. L.

Antioxidants and free radical scavengers, by combatting oxygen radical-mediated oxidative stress, may protect against ionising radiation. A total antioxidant assay has been developed using a highly fluorescent molecule, β-phycoerythrin (BPE), as the target for radiation generated free radicals. Serial dilutions of a solution of a test compound are made across a 96-well microwell plate and a standard BPE solution added to each well. Competition plots for combinations of BPE and scavenging compounds can then be generated by monitoring changes in fluorescence of the BPE solution in each well, before and after a radiation dose, as a function of compound concentration. As in other antioxidant assays one unit is defined as the quantity of antioxidant required to reduce by half the action of oxygen derived free radicals, in this case monitored by the fluorescence decay of a 340 ng mL^{-1} solution of β-phycoerythrin. The fluorescence decreases linearly with dose allowing radioprotective capacities to be determined after a single standard test dose. Using this technique, relative rate constants can be calculated for the reactions between hydroxyl radical scavengers and hydroxyl radicals. For antioxidants and hydrogen donors, there is a correlation between radioprotective capacity and oxidation potential. The assay then becomes a true measure of total radioprotective effect which can rank the compounds. Antioxidants are more than thirty times more effective than pure hydroxyl radical scavengers such as sugars, which is due to their competition with oxygen for the target radical intermediates. The antioxidant compounds could be ranked based on their chemical structure. Indoles, such as melatonin are the most effective (nine times more effective than ascorbic acid), followed by phenols and thiol compounds. The assay can also be applied to complex biological samples. Cell lysates and human blood plasma were measured to determine if variations in their radioprotective capacity could explain observed differences in cellular radiosensitivity. These samples proved to be highly reductive, more reductive than ascorbate on a weight per weight basis. For total blood plasma radioprotective effect an inverse trend was observed with donor age, which is largely due to high molecular weight protein contributions that are inefficient in their interaction with target radicals. However, only additions of a low molecular weight antioxidant (melatonin) were able to modify radioprotection in vitro.

Accurate Measurements Of The Collision Stopping Powers For 5 To 30 MeV Electrons (Dosimetry, Electron Collision)

Macpherson, Miller, PhD; Adviser: Ross, Carl K.

Accurate knowledge of electron stopping powers is crucial for accurate radiation dosimetry and radiation transport calculations. Current values for stopping powers are based on a theoretical model, with estimated uncertainties of 0.5-1% (1σ) for electron energies greater than 100 keV. This work presents the first measurements of electron collision stopping powers capable of testing the theoretical values within these stated uncertainties. A large NaI spectrometer was used to measure the change in electron energy when an absorbing disk of known thickness was placed in an electron beam. Monte Carlo simulations of the experiment were performed to account for the effects of surrounding materials. Energy differences between the calculated and measured spectra were used to determine corrections to the soft collision component of the theoretical stopping powers employed by the Monte Carlo simulations. Four different elemental materials were studied: Be, Al, Cu, and Ta. This provided a wide range of atomic numbers and densities over which to test the theory. In addition, stopping powers were measured for graphite (both standard and pyrolytic), A-150 tissue equivalent plastic, C-552 air equivalent plastic, and water. The incident electron energies ranged from 5 to 30 MeV. Generally, the measured stopping powers agree with the theoretical values within the experimental uncertainties, which range from 0.4% to 0.7% (1σ). Aluminum, however, exhibits a 0.7% discrepancy at higher electron energies. Furthermore, these measurements have established that the grain density stopping power is appropriate for graphite, contrary to the recommendations of ICRU Report 37. This removes a 0.2% uncertainty in air kerma calibrations, and impacts on dosimetric quantities determined via graphite calorimetry, such as G for Fricke dosimetry and (W/ e)air for ion chamber measurements.

A Comparison Of Pulsed Dose Rate To Low Dose Rate Irradiation With/Without Mild Hyperthermia Using Three Human Cell Lines

Niedbala, Malgorzata, MSc; Adviser: Raaphorst, G. Peter

Computer-controlled radiotherapy technology has motivated the investigation of pulsed dose rate as a replacement for conventional low dose

rate treatment. To determine whether different pulsed dose rate schemes could simulate low dose rate irradiation, radiosensitive and radioresistant ovarian carcinoma cells, and normal human fibroblasts were irradiated in vitro using different fraction sizes, 0.53 Gy, 1.1 Gy, 1.6 Gy, 2.1 Gy, and 3.2 Gy, and their corresponding time intervals, 1h, 2h, 3h, 4h, and 6h. Selected fraction sizes, 0.53 Gy and 1.6 Gy, in combination with mild hyperthermia were also investigated to determine if radiosensitization due to hyperthermia occurred. The survival of the cells was assessed using the clonogenic assay. The data showed that for the resistant cell line the shorter fractionation schemes were equivalent to low dose rate, while larger fractionation schemes had lower survivals than that for low dose rate, suggesting incomplete repair of radiation damage. The sensitive cell line showed this equivalence only with the 1.6 Gy fraction size. The normal cell line showed no equivalence between any of its pulsed dose rate schemes and low dose rate. For the pulsed dose rate experiments with mild hyperthermia, it was determined that hyperthermia did not radiosensitize the cells for the 0.53 Gy given every 1h fractionation scheme used, while it radiosensitized the carcinoma cell lines when using the 1.6 Gy fraction size, but not the normal cell line. This resulted in a potential clinical advantage for using the 1.6 Gy fraction size with mild hyperthermia.

Monte Carlo Investigation Of Electron Beam Relative Output Factors

Zhang, Geoffrey G., PhD; Adviser: Rogers, David

One of the tasks in commissioning an electron accelerator in cancer clinics is to measure relative output factors (ROFs) versus various parameters such as applicator size (called applicator factors), cutout size (cutout factors) and air-gap size (gap factors) for various electron beam energies and applicator sizes. This kind of measurement takes a lot of time and labour. This thesis shows that Monte Carlo simulation offers an alternative to this task. With BEAM (Med. Phys. 22(1995)503-;524), an EGS4 user-code, clinical accelerator electron beams are simulated and ROFs for a Siemens MD2 linear accelerator and a Varian Clinac 2100C accelerator are calculate The study shows that the Monte Carlo method is not only practical in clinics but also powerful in analyzing the related physics. The calculated ROFs agree within 1% with the measurements for most cases and 2% for all cases that have been studied, which is more than acceptable in clinical practice. The details of each component of the dose, such as dose from particles scattered off the photon-jaws and the applicator, the dose from contaminant photon, the dose from direct electrons, etc., are also analyzed. The study also explains quantitatively why the effective SSD (Source to Phantom Surface Distance) is often not the nominal reference SSD. For ROF measurements for small fields using an ion chamber, this study discusses the stopping-power ratio corrections due to changes in the depth of dose maximum as a function of field size and versus various accelerators. Since it handles ROF calculations for arbitrary fields, including square, rectangular, circular and irregular fields, in the same way, Monte Carlo is the simplest method to get ROFs compared to other algorithms. As the first step towards implementing Monte Carlo methods in clinical treatment planning, Monte Carlo calculations for electron beam ROFs can replace measurements in clinical practice. It takes about 6 hours of CPU time on a single Pentium Pro 200MHz computer to simulate an accelerator and additional 2 hours for each ROF.

Daltech-Dalhousie University

Automated Registration Of Three-Dimensional Data Sets

Secretta, Gleb, MASc; Adviser: Gregson, P. H.

There are many tedious tasks in medical imaging that can and should be automated. Often there is a need to observe and measure changes in structure or functioning of an internal organ. To perform this task images taken at different moments in time must be acquired with the same orientation of the imaging system with respect to the patient's body. The task of combining functional and structural data in one image is even more demanding because often images of different modalities also have different resolutions. This thesis proposes a new method for registration of brain images that meets the described requirements. The developed algorithm performs mathematical rotation and resampling of one 3-D data set to match the orientation and the sampling rate of the other data set. A new, light-weight adjustable reference system was designed to fit inside various scanners. Once adjusted, it can be mounted on a human head, taken off and then remounted in the same position. A new algorithm was developed to determine the position and orientation of the reference system inside the imaging system. (Abstract shortened by UMI.)

École Polytechnique, Montreal

Caracterisation Des Proprietes Elastiques De La Paroi Arterielle Par Ultrasonographie Endovasculaire

Soualmi, Lahbib, PhD; Adviser: Bertrand, Michel

This thesis deals with the endovascular elastography (EVE) which is a new ultrasonic imaging technique to characterize the elastic properties of the arterial wall tissue. The objective of this research is to develop a method able to characterize and quantify the arterial elastic properties, allowing the diagnosis of arterial pathologies. Atherosclerosis is this arterial pathology characterized by arterial wall thickening and loss of elasticity. It begins with the accumulation of atheroma (plaque) leading to the narrowing of the arterial lumen. EVE, by its capacity to distinguish between plaque types and characterize their hardness, would refine the diagnosis and the remedial interventions. It would be possible, with the theoretical model of EVE, to predict the response of the tissue to a procedure such as angioplasty. This would allow to predict any complication, as intimale tearing, assisting in the choice of an other more appropriate modality. As a first approximation, the arterial wall tissue, including plaques, is modeled as isotropic, incompressible and linearly elastic material. Since only the component of the displacement in the acoustical scanning plane is assessable, the model is considered in a plane strain state. The strain image, derived from the displacement field obtained after compressing the arterial tissue, is called the endovascular elastogram . With the assumption of constant stress field at the inner wall boundary, the strain field is considered as a relative measure of the elasticity distribution of the arterial wall. While the displacement measures are estimated from intravasacular sonograms, an echographic endovascular image formation model is proposed to study the artifact surrounding this kind of imaging system. To reduce the consequence of these artifacts and to obtain a quantitative representation of the elasticity distribution, we consider the EVE in the framework of an inverse problem (IP) solution. The IP is first solved using both the axial and lateral component of the displacement field. Using the Gauss-Newton method, in an ideal condition, the reconstruction of the elasticity distribution was successful. Subsequently, since in practice only the component of the displacement in the acoustical scanning plane can be measured, we use only the axial component of the displacement field to solve the IP. To solve the IP and single out a stable solution, Levenberg-Marquardt method is used. In this IP solving, we were able to retrieve an acceptable solution even in the case where we add a noise in the displacement data. When the signal to noise ratio (SNR) is greater than 30 dB the solution is admissible. (Abstract shortened by UMI.)

Guelph University

The Effects Of Initial Ankle Posture On Energy Return

And Impact Loading Characteristics

Bauman, Marvin, MSc; Adviser: Lafortune, M. A.

The repeated impact loading of the musculoskeletal system that occurs during running has the potential to cause injury. This research investigates initial ankle posture effects upon impact loading and energy return. Four initial ankle postures were used (12.5° of dorsiflexion; a flat-footed impact; 12.5° of plantarflexion; 25° of plantarflexion). A human pendulum modality (Lafortune and Lake, 1995c), which provided control of the initial impact conditions, was used to simulate running impacts. Impact force and tibial and head accelerations were recorded to quantify impact severity and energy return. A joint model was also developed to estimate ankle joint compressive loads at the time of the impact peak. The flatfooted contact produced the most severe impacts but the smallest joint force. The dorsiflexed ankle posture produced less severe impacts but larger joint forces. The two plantarflexed conditions resulted in the least severe impacts and the largest joint forces. The plantarflexed conditions were also more effective at storing and returning energy to the system.

Role Of 10- And 14-Carbon Alkanes In H(II) Phase Of DOPE

Cleve, Richard, MSc

Small, hydrophobic molecules such as n-decane and n-tetradecane are known to be inverse hexagonal (H_{II}) phase promoters. n-tetradecane also causes an increase in the hexagonal phase repeat distance whereas n-decane shows no change in the repeat distance. In this study NMR spectroscopy and NMR relaxation (T_{1z}], T_2qe, and T_2q-CPMG]) were used to study the perdeuterated $C_{10}D_{30}$ and $C_{14}D_{30}$ molecules in a DOPE-water system. The tetradecane spectrum and relaxation data showed very little change on reducing the water content from excess water to osmotically stressed, 87.5% weight. The decane showed a slight increase in order and a shortened T_2qe on osmotic stressing. These data are inconsistent with the existing 'space-filling' model. While no model can be constructed on the basis of this new data, the data provide constraints for new models of alkane-phospholipid interaction.

Preservation Of POPC Model Membrane Integrity By Trehalose. A Deuterium And Phosphorus-31 NMR Study

Hayne, Stewart, MSc; Adviser: Jeffrey, K. R.

The role of trehalose in maintaining model membrane integrity in the presence of dehydration via freezing or desiccation is investigated using nuclear magnetic resonance (NMR) techniques. ^{2}H NMR spectra were recorded for D_2O/POPC mixtures as a function of hydration and temperature to determine the hydration dependence of the gel to liquid crystal phase transition. ^{2}H NMR spectra were also recorded for deuterated head group POPC in the presence of trehalose as a function of temperature to investigate the influence of trehalose on the head group. It was found that adding trehalose resulting in an increase in the alpha position deuterium quadrupolar splitting. This is due to the trehalose changing the conformation of the headgroup, resulting in a change in average angle with respect to the surface of the lipid bilayer. From ^{31}P NMR spin-lattice relaxation and a model for the relaxation, an effective correlation time for the headgroup reorientation was determined as a function of temperature. From these data activation energies for the headgroup reorientation were determined for each hydration. From analysis of the correlation time data it appears that trehalose does influence the headgroup dynamic at low water content.

The Dynamics Of Peptide-16 In DMPC Bilayer Membranes: An NMR Relaxation Study (Cross Polarization, Magic Angle Spinning)

Qian, Jin, PhD; Adviser: Davis, James H.

NMR relaxation experiments are performed to investigate the dynamics of a model bilayer membrane: a synthetic amphiphilic peptide, Lys_2-Gly-Leu_{16}-Lys_2-Ala-amide (peptide-16) in fully hydrated DMPC bilayers. This peptide forms an α-helix in the lipid bilayer, and its length matches the thickness of the bilayer. We use this peptide to mimic the trans-membrane segment of a protein. The dynamics of the system is of great interest. We studied the slow motions of both DMPC and peptide by measuring the ^{13}C rotating frame relaxation times ($T_{1\rho}$) as well as the ^{13}C and ^{1}H lab frame relaxation times (T_1). Peptide carbonyl carbons were labeled with ^{13}C, while DMPC was studied at natural abundance. CP (Cross Polarization) and MAS (Magic Angle Spinning) techniques were used to enhance the signal to noise ratio. From our oriented samples (lipid bilayers oriented on glass plates), we measured the orientation dependence, the spin lock field dependence, and the temperature dependence of the rotating frame relaxation times. From the powder samples (lipid bilayers in the form of vesicles), we measured the spinning rate dependence, the offset frequency dependence, and the temperature dependence of the rotating frame relaxation times. Theoretical work was also developed to interpret our experimental results. For the peptide dynamics, we assumed a motion characterized by three correlation times τ_0, τ_1 and τ_2, where τ_0 is the correlation time of the function 3 $(\cos^2\beta\text{-}1)/2$, τ_1 is the correlation time of the function $\sin 2\beta\ e^{-i/\text{gamma}}$, τ_2 is the correlation time of the function $\sin^2\beta\ e^{-2i/\text{gamma}}$, and β and γ are the polar angles of the molecular fast diffusion axis in the local bilayer normal system, they are functions of time due to the slow motion. From our peptide measurement, we determine a slow motion with correlation times τ_0 ~60 μs, τ_1 7 μs and $\tau_2 < 4$ μs at temperature 40° C. At 50° C, τ_1 was about 4 μs. In this thesis, two totally different approaches were employed, the orientation dependence study and the MAS study. They complemented and supported each other, and the results of one were consistent with those of the other. This is the beauty of the present work. The methods we used (Cross Polarization, Magic Angle Spinning and spin lattice relaxation in the rotating frame) are technically challenging and represent an original contribution to the discipline. The correlation times we measured have broader significance to our understanding of the membrane and polypeptide dynamics, and to the understanding of membrane processes and physical properties.

Laval University

Pulsatile Laminar And Turbulent Blood Flow Simulation In Large Stenosed Arteries And Stenosed Carotid Artery Bifurcation (Atherosclerosis)

Ghalichi, Farzan, PhD; Adviser: Dechamplain, Alain

In this dissertation, the effect of a minor and a severe stenosis was studied on various aspects of flow downstream of stenosis in a femoral artery and a human carotid artery bifurcation. The major parameters of interest were the time-averaged velocities, time-dependent shear stress, separation zone and reattachment length. We did believe that the numerical results of laminar flow simulation beyond the critical Reynolds number were not reliable. Therefore, a new methodology had to be used to provide new numerical information. We found that low-Re k-Ω turbulence model was appropriate with accurate data to simulate blood flow in the entire flow domain. The predicted results by the low-Re model were in very good agreement with the experimental measurements. In the second part of this thesis, the evolution of atherosclerotic disease was studied under the presence of various degrees of stenosis. The role of carotid artery bifurcation geometry was also taken into account. The finite element calculations of the stenosed carotid artery bifurcation were performed under laminar flow conditions at a mean Reynolds number of 200 and a flow division ratio of about 70/30, simulating an entire systolic and diastolic pulse wave. The presence of a stenosis greater than 25% created two distinct flow zones in the inter-

nal carotid artery, a high wall shear stress area at the stenosis, and an elongated flow recirculation zone with low wall shear stress leading to increased duration of flow reversal in a pulse cycle which retards mass transport through the arterial wall and may in turn accelerate the development of atherosclerosis downstream of the stenosis. Furthermore, the results showed that the atherosclerotic lesions may develop very rapidly up to a stenosis of between 25% and 40%. Beyond 40% and up to 75% stenosis, the development of lesions occurred but not at the same rate as before. The 75% stenosis showed significant variations in flow behavior leading to a fast progression of atherosclerotic lesions. These findings have prompted us to pursue our study for a more severe stenosis. The presence of a >=70% stenosis does change the laminar flow regime to turbulent flow. Low-Re turbulence modeling was applied in the pulsatile flow simulation to detect laminar and turbulent flow regimes. The results showed that even in a healthy artery, weak instabilities could be found at least for a portion of the pulse cycle and in different areas. The presence of 40% and 55% stenoses in both test models did not alter significantly the flow properties with regard to turbulence. On the other hand the presence of a 75% stenosis altered the flow properties from laminar to turbulent. (Abstract shortened by UMI.)

Caracterisation Et Simulation De La Migration Des Sources Dans Le Traitement Par Implants Permanents Transperineaux Du Cancer De La Prostate

Taschereau, Richard, MSc; Adviser: Roy, Rene

Le traitement du carcinome de la prostate par implantation transperineale permanente de sources radioactives connait une popularite grandissante en Amerique du nord. La migration des sources est le nom donne a l'ensemble des phenomenes causant une erreur de positionnement des sources radioactives, pendant ou apres l'implantation. La caracterisation de la migration etablit que la cause principale de mauvais positionnement est un deplacement longitudinal cause par la friction entre les tissus et l'aiguille utilisee pour l'insertion. Ce deplacement degrade la qualite de l'implant. L'indice de qualite 'dose volume histogram' passe de plus de 99% en previsionnel a 82% en post-implant. Un programme de simulation par ordinateur est developpe a partir de la caracterisation. Le programme genere de facon aleatoire un ensemble d'implants simules sur lesquels sont mesures les indices de qualite. L'utilisation du programme permet d'ameliorer la technique en la rendant moins sensible a la migration.

McGill University

Experimental Characterization Of A Low-Dose-Rate And A High-Dose-Rate Iridium-192 Brachytherapy Source Using The AAPM TG 43 Dosimetry Protocol

Anctil, Jean-Claude, MMRP; Adviser: Clark, Brenda G.

Current brachytherapy dosimetry protocols assume that a physical source may be approximated by a point source. A new brachytherapy dosimetry protocol, recently proposed by the American Association of Physicists in Medicine Task Group 43, has the advantage of using functions derived solely from measurements performed in the medium and uses a more realistic source geometry than the point source approximation. The aim of this work is to obtain the dosimetric functions required by this new protocol for both a low and a high dose-rate Iridium-192 brachytherapy source through dose measurements in a water-equivalent phantom. Dose measurements have been performed using lithium fluoride thermoluminescent detectors positioned in a polystyrene phantom at distances from the source that vary from 1 cm to 10 cm, with 1-cm intervals, and at angles that vary from 0° to 170° with 10° intervals. Our experimental results have clearly shown that the point-source approximation model can overestimate the dose to water, especially for the high dose-rate source, where we have found that differences between point-source estimates and exact measured values can differ by almost 30% for points along the longitudinal axis of the source.

Les protocoles actuels de dosimétrie de la curiethérapie utilisent I'approximation d'une source ponctuelle. Un nouveau protocole de dosimétrie applicable à la curiethérapie, proposé par le groupe de travail 43 de l'American Association of Physicists in Medicine, présente I'avantage d'utiliser des fonctions obtenues par des mesures effectuées entièrement dans un milieu comme 1'eau, et, de plus, fait appel à une configuration géométrique plus réaliste des sources radioactives. La présente étude a été entreprise dans le but d'obtenir les fonctions dosimétriques du nouveau protocols associées à deux sources radioactive d'Iridium-192, soit une source de bas débit de dose et une source de haut débit de dose, et ce au moyen de mesures de dose dans un fantôme de matériel equivalent en eau. Les mesures de dose ont été effectuées à l'aide de détecteurs thermoluminescents au fluorure de lithium placés dans un fantôme de polystyrène pour des distances variant de 1 à 10 cm, par intervalles de 1 cm, et pour une couverture angulaire variant de 0º à 170º, par intervalles de 10º. Nos résultats expérimentaux ont clairement démontré qu'un protocol dosimétrique utilisant I'approximation ponctuelle de la source radioactive peut surestimer la dose à 1'eau de près de 30% pour des points de calcul situés dans l'axe longitudinal d'une source à haut débit de dose.

Queen's University

The Compressive Characteristics Of The Glenoid Labrum

Carey, Jason P. R., MSc; Adviser: Small, C. F.

The objective of this research was to compare the compressive load versus displacement responses of the glenoid labrum using rapid indentation and obtain the stiffness and modulus of the tissue. The compressive testing procedure was a novel method of testing soft tissue in situ. Stiffness findings validated the testing procedure. Six embalmed and nearly intact labra were tested in six morphologically different sections delimited by other researchers as being susceptible to different injuries. Each section was indented at three sites. Results of the indentation testing demonstrated large differences in the stiffness and modulus between the superior and inferior sections of the glenoid labrum. The stiffness results showed some similarities within sections and confirmed the variability between various portions of the tissue. The modulus was defined as the stress applied to the tissue by the indentor divided by the ratio of displacement and the tissue thickness. The labral modulus ranged from 0.11 ± 0.16 to 0.41 ± 0.32 MPa. The cartilage modulus ranged from 1.65 ± 0.78 to 4.82 ± 2.93 MPa. The inferior section of the labrum was the least stiff as a material. This could imply that the lower section is less important for load bearing. Results from the second linear portion of the data were in the range of previous findings for articular cartilage. Using actual cartilage thickness values the calculated cartilage moduli ranged from 1.29 to 2.00 MPa. These results are comparable to the previous studies. Specimen morphology findings agreed with most previous studies. The labrum added 5mm to the anterior posterior depth of the glenoid fossa. Gross observation of the specimens confirmed the larger occurrence of tissue damage in the superior portion of the labrum. Large differences were found between the dominant and non-dominant arm of each cadaver. However, these differences were less than those found between cadavers. (Abstract shortened by UMI.)

Noninvasive Diagnosis Of Acute Compartment Syndromes Using Ultrasound And Mechanical Vibration: Feasibility Study

Dellah, Aaron, MSc(Eng); Adviser: Small, Carolyn

Acute compartment syndrome is a rare limb-threatening condition characterized by the fluidic pressurization of muscle compartments bound by inextensible tissues. The etiology and current diagnostic techniques for compartment syndromes were reviewed and morbidity, time dependency and clinical uncertainty were identified as the factors warranting the need for a non-invasive diagnostic technique. Following a review of the literature and analysis of existing and proposed new techniques, the 'mechanical response technique' using a vibratory stimulus and ultrasound imaging was selected for the feasibility study. A simple mechanical model was designed to simulate a compartment syndrome. The model consisted of two concentric cylinders pressurized with water representing a muscle compartment inside a limb-like structure. Compartment pressures were varied and the model was subjected to mechanical vibration. The motion of the compartment walls was monitored with ultrasound imaging. A pilot study was performed to determine which parameters were best suited for measuring compartment motion. A second study measured the displacement amplitude of the compartment wall closest to the source of a 5 Hertz vibration. The 'limb' pressure was held constant at 7mmHg and the 'compartment' pressure varied from 0 to 45mmHg relative to the limb. Displacement amplitudes were found to initially decrease with increased compartment pressure and then remain constant. The system response was approximated using a mass-spring-damper model. The data proved that the 'mechanical response' technique was a promising idea warranting further research. The success of the experiment was considered limited because of the simplicity of the mechanical model. It was recommended that a better compartment syndrome model be developed, and further improvements be made to the vibration and ultrasound data collection components of the study.

Inverse Problem Approach To Ultrasound Medical Imaging (Propagation Velocity)

Javanmard, Mehdi, PhD; Adviser: Bayou-I, M. M.

In this thesis a new theory is proposed to develop a pulse-echo ultrasound framework, without an a priori accurate estimate of propagation velocity of the imaging medium, that can be used in ultrasound medical imaging. The theory is a hybrid approach in which basic equations of acoustic scattering and wave diffraction theory are used to extrapolate the propagated part of the acoustic pressure field back to the transducers while a probabilistic method is used to estimate the acoustic propagation velocity profile of the imaging medium. Various simulation examples are designed to demonstrate the data acquisition procedure, the steps of the suggested framework, and its use.

Calibration And Point-Based Registration Of Fluoroscopic Images

Tang, Thomas Shu Yin, MSc; Adviser: Ellis, Randy

The problem addressed in this thesis is the fast and accurate registration of a set of 3D radio-opaque markers to a fluoroscopic X-ray image. There are three significant hurdles to be overcome in solving this problem: fluoroscopic images are distorted by external magnetic fields; the mechanical beams of the fluoroscope deform differently in different orientations, and simple registration algorithms converge slowly. It is possible to decouple these effects and solve each sub-problem independently. A grid of small spheres was used to develop a local linear model of image deformation, and a method of interpolating between grid points was used to refine the accuracy of the deformation model. Next, using the corrected image and a calibration phantom, the three-dimensional location of the X-ray source was deduced. Finally, an efficient optimization algorithm was used to determine the location and orientation of the set of markers. Experimental results showed that the image-correction methods achieved sub-millimeter accuracy, and the error of recovered poses was found to be less than 1° in orientation and 2 mm in position. The process is fast and accurate enough for use in an operating room during computer-assisted surgical procedures.

University of Alberta

A Physical Model For Broadband Ultrasonic Studies Of Cancellous Bone

Ji, Qing, PhD; Adviser: Filipow, L. J.

A physical model to describe ultrasonic wave propagation in cancellous bone has been described in this thesis. The theoretical background for this model is based on Biot's theory. In order to prove the effectiveness and accuracy of this model, a broadband ultrasonic experimental system to study the ultrasonic properties of porous media was built as part of this project. The configuration details of this system as well as the fundamental techniques of measuring the attenuation and propagation velocities in a medium are presented in this thesis. The results of ultrasonic studies on water-saturated aluminum foams, which were used extensively as cancellous bone phantoms for studying basic mechanisms of wave propagation, and a detailed theoretical analysis of these experimental results are also presented. The experiments agree very well with the physical model established in this study. To extend this physical model to cancellous bone, several bovine bone samples and two types of cancellous bone phantoms were tested. The results of these experiments are also analyzed by the model.

University of British Columbia

Water-Fat Imaging And General Chemical Shift Imaging With Spectrum Modeling

An, Li, PhD; Adviser: Qing-San Xiang

Water-fat chemical shift imaging (CSI) has been an active research area in magnetic resonance imaging (MRI) since the early 1980's. There are two main reasons for water-fat imaging. First, water-fat imaging can serve as a fat-suppression method. Removing the usually bright fatty signals not only extends the useful dynamic range of an image, but also allows better visualization of lesions or injected contrast, and removes chemical shift artifacts, which may contribute to improved diagnosis. Second, quantification of water and fat provides useful chemical information for characterizing tissues such as bone marrow, liver, and adrenal masses. A milestone in water-fat imaging is the Dixon method that can produce separate water and fat images with only two data acquisitions. In practice, however, the Dixon method is not always successful due to field inhomogeneity problems. In recent years, many variations of the Dixon method have been proposed to overcome the field inhomogeneity problem. In general, these methods can at best separate water and fat without identifying the two because the water and fat magnetization vectors are sampled symmetrically, only parallel and anti-parallel. Furthermore, these methods usually depend on two-dimensional phase unwrapping which itself is sensitive to noise and artifacts, and becomes unreliable when the images have disconnected tissues in the field-of-view (FOV). We will first introduce the basic principles of nuclear magnetic resonance (NMR) and magnetic resonance imaging (MRI) in chapter 1, and briefly review the existing water-fat imaging techniques in chapter 2. In chapter 3, we will introduce a new method for water-fat imaging. With three image acquisitions, a general direct phase encoding (DPE) of the chemical shift information is achieved, which allows an unambiguous determination of water and fat on a pixel by pixel basis. Details of specific implementations and noise performance will be discussed. Representative results from volunteers and patients in a clinical setting will be presented. In chapter 4, new improvements in the signal-to-noise-ratio (SNR) for the DPE method will be introduced and details of noise performance analysis will be discussed. In chapter 5, a special DPE sampling scheme will be introduced. With three-orthogonal phase (TOP) image acquisitions, it allows a correction of image magnitude errors caused by factors such as T_2^* relaxation. Details of data acquisition and signal

processing will be discussed. Representative results from volunteers will be presented. In chapter 6, we will introduce a new two-point water-fat imaging method. By sampling water and fat asymmetrically and minimizing the gradient energy in a phase map, this method determines water and fat without ambiguity and handles disconnected tissues well. Details of data acquisition, signal processing, and noise performances will be discussed. Representative results from volunteers will be presented. In chapter 7, we will introduce a new general method of chemical shift imaging with spectrum modeling (CSISM). CSISM models a spectrum as several peaks with known resonance frequencies but unknown peak amplitudes which can be resolved from a set of spin-echo images. Details of data acquisition, signal processing and noise performances will be discussed. Representative results from phantom experiments and a clinical scan will be presented. In chapter 8, the general ideas, results and conclusions of all the methods we introduced in this thesis will be discussed, compared, and summarized.

Proton Magnetic Resonance Of Lung (Collagen)

Estilaei, Mohammad Reza, PhD; Adviser: Mackay, A.

Proton nuclear magnetic resonance ^{1}H NMR was used to investigate the entire signal from excised lung tissue. The free induction decay signal contained a motionally restricted component which decayed in a few 10's of μs and a mobile component which persisted about 10 ms or longer. The motionally restricted component was characterized by the second moment of its lineshape which had an average value of 3.42 ± 0.25 x 10^9 s^{-2}. This value was about 1/3 of the rigid lattice M_2 value, indicating that long: macromolecules undergo considerable anisotropic motion on the NMR timescale. The mobile component of the lung was characterized by its T_2 relaxation times which relate to the microscopic tissue environment. Due to the inhomogeneous nature of the structure and biochemical composition of lung, a smooth T_2 distribution was assumed. The mobile signal consistently showed four resolvable components of T_2 range: 2-6, 10-40, 80-110, and 190-400 ms. The 2-6 ms component was present in a fully dehydrated preparation and was therefore assigned to a non-aqueous lung constituent. Collagen is a major protein present in lung tissue and has high tensile strength, rigidity and binding affinity for water. For this reason, the dependence of the second moment, T_2 relaxation times, and T_2 relaxation amplitudes on collagen content were studied. To determine the lung wet/dry ratio, the hydrogen content per unit mass for lung parenchyma and water were estimated in two ways: (1) on the basis of chemical content, and (2) on the basis of comparison of restricted and mobile signals to the gravimetric (G) water content for a lung-sample studied at a wide range of water contents. Lung Wet/Dry weight ratios were estimated from the free induction decays and compared with gravimetric measurements. The ratio of $(Wet/Dry)_{NMR}/(Wet/Dry)_G$ was 1.00 ± (0.08) and 1.00 ± (0.05) for the two methods of estimation. The water content measurements were validated and T_2 distributions were determined in inflated, deflated, and perfused lungs on a clinical 1.5 T MRI scanner. The mean difference between the gravimetric and MRI water contents was -4.1g ± 7.6% and an excellent linear correlation squared (R^2=0.98) was observed between the two independent measurements. A spherical shell model was tailored to characterize the susceptibility-induced magnetic field gradients in inflated lung and a simulation was performed to assess the effect of diffusion alone on the T_2 decay curve. This approach demonstrated that the multiexponential nature of the T_2 distribution was largely due to diffusion of water molecules in the magnetic field gradients. This study also enabled measurements of the inherent T_2 relaxation. The estimation of the magnetic field gradients facilitated measurement of the apparent diffusion coefficient by collecting images at a fixed imaging time using a multiecho pulse sequence with different echo spacing. The apparent diffusion coefficient decreased from about $1.1x10^{-5}$ cm^2/s to $1.7x10^{-6}$ cm^2/s as diffusion time increased from 12 to 60 ms. (Abstract shortened by UMI.)

The Design and Development of a Phantom for use in Dynamic SPECT Imaging

Farncombe, Troy, MSc; Adviser: Anna Celler

It has been suggested that the rate of tracer extraction from certain organs reflects the functional ability of that organ. The determination of the kinetic rates associated with extraction could therefore potentially provide a useful measure of organ function and could help in the diagnosis of disease. Dynamic SPECT is one imaging modality that attempts to determine these kinetic rates in three dimensions. A dynamic heart-in-thorax phantom has been developed for testing dynamic SPECT reconstruction methods. This phantom consists of a plastic myocardial volume containing smaller "defect" volumes, and a central blood pool. Surrounding the heart phantom is a larger thorax phantom which provides a non-uniform attenuating medium. The heart volumes are loaded with activity and washed out with water, thus producing the same type of activity decay that is seen to occur in the metabolism of fatty acids in the myocardium. By varying the flow rate of water into the phantom, different washout times can be obtained. Additionally, the phantom can be used in a variety of applications including multiple exponential decay and the investigation of input functions. Testing of the phantom using both planar dynamic and image based SPECT protocols show that the phantom accurately reproduces preset washout rates to within 10\%. With this level of accuracy attained, we feel the phantom can confidently be used in the development of new dynamic SPECT reconstruction algorithms.

Asymmetric Collimation: Dosimetric Characteristics, Treatment Planning Algorithm, And Clinical Applications

Kwa, William, PhD; Adviser: El-Khatib, Ellen

In this thesis the dosimetric characteristics of asymmetric fields are investigated and a new computation method for the dosimetry of asymmetric fields is described and implemented into an existing treatment planning algorithm. Based on this asymmetric field treatment planning algorithm, the clinical use of asymmetric fields in cancer treatment is investigated, and new treatment techniques for conformal therapy are developed. Dose calculation is verified with thermoluminescent dosimeters in a body phantom. In this thesis, an analytical approach is proposed to account for the dose reduction when a corresponding symmetric field is collimated asymmetrically to a smaller asymmetric field. This is represented by a correction factor that uses the ratio of the equivalent field dose contributions between the asymmetric and symmetric fields. The same equation used in the expression of the correction factor can be used for a wide range of asymmetric field sizes, photon energies and linear accelerators. This correction factor will account for the reduction in scatter contributions within an asymmetric field, resulting in the dose profile of an asymmetric field resembling that of a wedged field. The output factors of some linear accelerators are dependent on the collimator settings and whether the upper or lower collimators are used to set the narrower dimension of a radiation field. In addition to this collimator exchange effect for symmetric fields, asymmetric fields are also found to exhibit some asymmetric collimator backscatter effect. The proposed correction factor is extended to account for these effects. A set of correction factors determined semi-empirically to account for the dose reduction in the penumbral region and outside the radiated field is established. Since these correction factors rely only on the output factors and the tissue maximum ratios, they can easily be implemented into an existing treatment planning system. There is no need to store either additional sets of asymmetric field profiles or databases for the implementation of these correction factors into an existing in-house treatment planning system. With this asymmetric field algorithm, the computation time is found to be 20 times faster than a commercial system. This computation method can also be generalized to the dose representation of a two-fold asymmetric field whereby both the field width and length are set asymmetrically, and

the calculations are not limited to points lying on one of the principal planes. The dosimetric consequences of asymmetric fields on the dose delivery in clinical situations are investigated. Examples of the clinical use of asymmetric fields are given and the potential use of asymmetric fields in conformal therapy is demonstrated. An alternative head and neck conformal therapy is described, and the treatment plan is compared to the conventional technique. The dose distributions calculated for the standard and alternative techniques are confirmed with thermoluminescent dosimeters in a body phantom at selected dose points. (Abstract shortened by UMI.)

Probing Nanoscale Adhesion And Structure At Soft Interfaces (Force Sensitivity)

Ritchie, Kenneth, PhD; Adviser: Evans, Evan

Physical measurement at soft interfaces presents special problems. The compliance of the interface makes positional accuracy of secondary importance to force sensitivity. Only minuscule forces are required to displace a soft surface or to slowly overcome a small energetic barrier in an aqueous environment. The thesis is organized according to three aspects of measurement at soft interfaces and the parts are labelled by Roman numerals I-III. Each of these parts (I-III) contains results, conclusions and discussions specific to the particular topic of the segment. (I) To test adhesion and probe compliance at soft interfaces, the development of a general, ultra-sensitive force measurement technique is described. The technique exploits a tunable force transducer comprised of a biomembrane capsule held under tension chemically bonded to a glass microsphere probe. The technique has a high sensitivity (in the range of pico- to nano-Newtons) and a large span of force loading rates. (II) To demonstrate nanoscale mechanical testing of interfacial compliance, the ultra-sensitive force probe was used to determine the thickness compressibility of the human red blood cell membrane. The membrane was found to be 100-fold softer than an ideal rubber. The minimum thickness of the red cell membrane was 58 ± 4 nm. This thickness implies that there are large proteins associated with the membrane that act to expand the tethered spectrin network. (III) To demonstrate nanoscale testing of molecular adhesive strength, the probe has been used to rupture single receptor-ligand bonds (avidin-biotin). Recognizing that thermal activation underlies dissociation of weak bonds, a theory for the force-driven failure of point physical bonds is presented. The predictions from theory are verified by Brownian dynamics simulation. Bond failure is a kinetic process. The experimentally measured strength of the bond depends on the rate which force is applied to the linkage. A universal logarithmic rate dependence regime reveals information about the underlying bonding potential along the force-driven reaction pathway. The form of the strength over a spectrum of loading rates gives the position and height of major energetic barriers along the bond failure pathway. Complex bonding potentials can thus be partially reconstructed and compared to the structures of the bonding species, if available.

The Development Of Multiple Line Transmission Sources For SPECT (Imaging Systems)

Sitek, Arkadiusz, PhD; Adviser: Celler, Anna

In this work a new kind of transmission source for SPECT imaging, based on multiple line sources, is presented. The source may be used for either simultaneous or sequential SPECT transmission imaging to measure patient specific attenuation maps. Two different, new transmission sources based on the multiple line concept, the collimated line sources and the multiple line array, were proposed and tested using computer simulations. Based on simulations, prototypes of the transmission sources were built, and series of experiments were performed. Computer simulations and experiments showed that multiple line transmission sources provided accurate attenuation maps. Compared with other transmission sources, the multiple line transmission sources do not require complicated hardware or expensive maintenance, but still give good quality attenuation maps. The multiple line array transmission source has been adopted for commercial use by Siemens Medical Systems with their ecam SPECT camera.

Investigating Models For Cross-Linker Mediated Actin Filament Dynamics

Spiros, Athan Andrew, PhD; Adviser: Keshet, Leah

Actin, a major component of the cytoskeleton, is responsible for the shape and structural properties of many eucaryotic cells. Actin filaments are made of monomers which bind in a single strand. Cross-linkers bind two filaments together and influence the relative orientation of the filaments. Cross-linkers such as α-actinin favor parallel alignment of filaments, while others such as actin-binding protein favor orthogonal alignment. The filament length, concentration of cross-linkers and cross-linker association-dissociation rates all affect the types of network that form. The resulting network dictates the structural properties of the cell. In this thesis I study how filament length, concentration of cross-linkers and crosslinker association-dissociation rates influence actin network development. I use existing models and create new models to explore these interactions. Integro-partial differential equations and other techniques are used to model the system. Using experimentally determined biological parameters. I predict the geometry and distribution of the resulting network. Computer simulations verify the model predictions. I compare these predictions with experimental results. Increasing the cross-linker concentration first strengthens the isotropic network, but then, beyond a transition, forces the network to be inhomogeneous and more fluid-like. As the cross-linker concentration increases even further, more filaments bind to the network, resulting in a stronger, more solid actin solution. Decreasing the cross-linker dissociation rate constant has the same effects as increasing the cross-linker concentration. Finally, I find that changing the filament length greatly affects rates of diffusion, influencing instabilities. Increasing the filament length, favors alignment and clustering, as well as formation of bundles. Filament length influences the spacing between clusters. Increasing the length, forces clusters to be spaced further apart until they eventually disappear. I also find that there is an optimal length for bundle formation. When considering a distribution of filament lengths, I expect to see a wider dispersal of filaments near the bundle transition point.

Magnetic Resonance Of Human And Bovine Brain (Magnetization Transfer, Myelin)

Vavasour, Irene, PhD; Adviser: Mackay, Alex

Magnetic resonance imaging (MRI) has become an invaluable tool for studying brain and its associated pathologies. Multiple sclerosis (MS) is one such pathology and attempts are being made to use MRI to characterise the myelination state of MS lesions. Two techniques have been proposed which appear to be sensitive to myelination: magnetization transfer (MT) and T_2 relaxation. Quantification of these techniques uses magnetization transfer ratios (MTR) for MT and myelin water percentages for T_2 relaxation. If the two techniques are both related to myelin content then they are expected to be related to each other. It was found by in vivo MRI measurements that white matter from normal volunteers and normal appearing white matter from MS patients had significantly larger MTRs and myelin water percentages than grey matter. However, only a weak correlation was found between MTRs and myelin water percentages in MS lesions ($R = 0.5, P = 0.005$) indicating that each technique provides an independent measure of MS pathology. Since water in white matter resides in two main compartments, in intra/extracellular spaces and between myelin bilayers, it was thought that MT would have a different effect on each water pool. This was examined by combining a T_2 relaxation sequence, which separates the two water pools, with an MT pulse. It was found using in vivo MRI measurements on normal human white matter that the myelin water pool was significantly more affected by an MT pulse than the intra/

extracellular water pool (P = 0.00001 to P = 0.04 for different white matter structures). It was also found that small offset frequencies caused more direct saturation of the myelin water pool than the intra/extracellular pool resulting in different contrast. Finally, at long delay times between the MT pulse and the initiation of the T_2 relaxation sequence (>500 ms), the difference in MT between the two pools was eliminated indicating exchange within that timescale. In vitro experiments on bovine brain were performed on a ^{1}H-NMR spectrometer. A 4-pool model was proposed to explain the different relaxation times measured in bovine white matter. These pools included intra/extracellular water, myelin water, non-myelin molecules and myelin molecules. Exchange between the myelin water and myelin, and the intra/extracellular water and non-myelin molecules were rapid with the former being slightly faster than the latter. There was no evidence for exchange between the two water pools within the timescale of 1 s. For human brain, a diffusion model was proposed to investigate exchange between the water pools. Results showed that variations in parameters associated with the intra/extracellular water pool affected only that pool. Variations in the myelin water pool, however, influenced the relaxation times and amplitudes of both water pools. Finally, it was found that changes in the axonal diameter and myelin thickness resulted in changes in the myelin water percentages and T_2 relaxation times. This could account for some of the differences in myelin water percentages and T_2 times measured in different white matter structures in the human brain.

University of Calgary

Improvement Of SPECT Using Radionuclide Transmission Attenuation Maps (Transmission Attenuation)

Dey, Damini, PhD; Adviser: Hahn, L. J.

The diagnostic accuracy of Single Photon Emission Computed Tomography (SPECT) is limited by physical effects such as photon attenuation and scatter, and the lack of anatomical reference corresponding to the SPECT images. Since the heart is surrounded by organs of varying density, attenuation correction in cardiac SPECT, in particular, requires measured attenuation maps. These are commonly obtained by radionuclide transmission (RNT) imaging, using transmission line sources. The goal of this work is to critically evaluate different methods and approaches to improve SPECT images corrupted by non-uniform attenuation and scatter, using RNT attenuation maps. Another objective is to evaluate unconventional use of RNT attenuation maps, in the integration of SPECT with anatomical CT data. SPECT scans simulating normal and defect myocardial studies of an anthropomorphic phantom were acquired. X-ray CT images and RNT attenuation maps of the phantom were also obtained. The effect of using Ordered Subsets Expectation Maximization (OSEM) and Chang's attenuation correction was quantitatively compared using this data. The effect of using attenuation maps obtained from poor quality RNT images, acquired using a transmission flood source, to using CT and scanning transmission line source attenuation maps, was also quantitatively compared. To perform these comparisons, it was necessary to register the SPECT and CT images. A novel, fully automated method for three-dimensional registration of SPECT and CT images, utilizing RNT attenuation maps, was used in this thesis. This image registration method was evaluated and found to be comparable to registration using fiducial markers.

OSEM and Chang's attenuation correction are found to be quantitatively equivalent, with comparable calculation times. However, OSEM attenuation correction provides a more correct radiotracer distribution and is, therefore, preferred. Attenuation maps obtained from poor quality RNT images are comparable to CT and scanning transmission line source attenuation maps, and can be used in cardiac SPECT without significant loss in quantitative accuracy. In addition, RNT attenuation maps can be utilized for robust, automatic three-dimensional SPECT-CT registration. This registration method is independent of features or quality of the SPECT images and avoids difficulties associated with fiducial markers. It can potentially be extended to SPECT imaging of various organs.

Gabaergic Inhibition Regulates The Synaptic Activation Of Cholinergic-Dependent Plateau Potentials

Doll, Daniel, MSc; Adviser: MacVicar, Brian

The cholinergic-dependent plateau potential (PP) is a prolonged depolarization of hippocampal CA1 pyramidal neurons. The PP can be generated synaptically in CA1 pyramidal neurons of the hippocampal slice following stimulation of the Schaffer collaterals. To reliably activate the PP synaptically both $GABA_A$ and $GABA_B$ receptors need to be blocked in the presence of a muscarinic receptor agonist. The intrinsically and synaptically evoked PP appear to be generated by the same mechanism. Intracellular BAPTA perfusion prevents the generation of the PP and an increase in conductance is seen during the onset of the synaptically activated PP. In contrast, blocking L-type calcium channels prevents the intrinsic but not the synaptic activation of the PP. Blocking NMDA receptor channels as a source of calcium entry has no effect on the synaptic generation of the plateau potential.

Interactions Between The Inwardly Rectifying Potassium Channels K(Ir)2.1 And K(Ir)3.4

Hay, Robert, MSc; Adviser: Duff, H. J.

Xenopus oocytes were injected with inward rectifier potassium channel RNAs for either Kir2.1, Kir3.4, or Kir2.1/Kir3.4. Resulting currents were analyzed with the following properties being measured: current level, extracellular (K^+) sensitivity, negative slope conductance, conductance-voltage relationship, and time-dependence of activation. In addition, Kir2.1 was also co-injected with either Kir3.4 or the Kir2.1/Kir3.4 chimeras. Currents fell into one of two categories. Kir2.1-like currents were large and showed sensitivity to K^+_{out}, negative slope conductance, saturation of conductance at -120 mV, and a time-dependence of activation. Kir3.4-like currents were smaller and showed none of these properties. Analysis of chimeric channels revealed that the N-terminus and pore regions of Kir3.4 were necessary to produce Kir3.4-like properties. Finally, co-expression results suggested that Kir2.1 and Kir3.4 do not interact to form a functional channel and that the pore and C-terminal regions determine the presence or absence of an interaction.

Molecular And Biophysical Analysis Of The Delayed Rectifier K+ Current In Bullfrog Atrium (Potassium Current, MinK)

Lowes, Vicki L., PhD; Adviser: Giles, Wayne

There is widespread interest in identifying the molecular structures underlying the slowly activating delayed rectifier K+ current (IKs) in cardiac tissue. At the time this dissertation was started minK, a small 129 amino acid polypeptide, was proposed to encode IKs. There was a controversy, however, over whether minK formed a functional K+ channel or acted as a regulator of protein(s) endogenous to Xenopus oocytes. The aim of this study was to provide a detailed quantitative comparison of the biophysical, pharmacological, and molecular properties of IKs with those of minK, to gain insight into whether minK could be responsible for IKs. The bullfrog atrium was used as a model of IKs, as the delayed rectifier K+ current in this tissue (IK) is composed of only a single slowly activating K+ conductance. IK was recorded from isolated bullfrog atrial myocytes using standard whole cell patch clamp techniques. The characteristics of this current were compared to two-electrode voltage clamp recordings of rat uterine minK expressed in Xenopus oocytes. IK and minK had very similar steady-state activation characteristics, current-voltage relationships, and selectivity for K+ ; and both exhibited similar pharmacological sensitivity to the class III antiarrhythmic agents, azimilide and propenamide. These results suggest that minK forms at least part of the molecular structure underlying

I K. Attempts to obtain evidence that minK is present in bullfrog atrium were unsuccessful, although two 3' splice variants of KvLQT1 were identified from bullfrog heart. KvLQT1 has recently been reported to coassemble with minK to encode IKs. At this time we have not been able to obtain functional expression of either splice variant. During this study, we noted that efflux of K+, due to activation of either minK or Kv1.2 expressed in Xenopus oocytes, caused significant depolarizing shifts in reversal potential, consistent with there being K+ accumulation on the extracellular surface of the oocyte. A mathematical model was developed showing that a restricted diffusion layer on the surface of the oocyte, in combination with an unstirred fluid layer, can account for the K+ accumulation.

Region-Based Adaptive Image Processing Techniques For Mammography

Shen, Liang, PhD; Adviser: Rangayyan, R. M.

As approximately one in twelve women in the western world suffer from breast cancer at some time in their lives, screening programs based on mammography have been instituted in most of western countries. The processing of X-ray mammographic images is technically one of the most challenging applications of digital image processing, largely because of the high degree of variability associated with both normal and abnormal diagnostic patterns. The advent of digitally-acquired mammograms offers the possibility of improvements in early breast cancer detection as well as readiness for digital image processing and teleradiology. Although digital mammography is still in the trial stage, computer-aided diagnosis with digitized mammographic images has shown its potential and advantages in breast cancer detection and management in terms of mammographic feature enhancement, computer-aided interpretation, and image archival. The thesis presented herein addresses all of the above issues with region-based adaptive image processing techniques. First, a region-based adaptive contrast enhancement method is introduced for improving the visibility of mammographic features, and its potential of diagnostic performance improvement in early detection of breast cancer is demonstrated based on the two Receiver Operating Characteristics (ROC) analyses. Then, shape-based analysis of microcalcifications and asymmetric density patterns is presented and their effectiveness is demonstrated. Finally, lossless image data compression with a segmentation-based technique and an additional transformation-based technique to improve the Joint Bi-level Image experts Group (JBIG) coding technique are presented, and shown to outperform other advanced, popular lossless compression methods.

An Image Processing Approach For Motion Artifact Suppression In Magnetic Resonance Imaging

Yang, Weifang, MSc; Adviser: Smith, M. R.

In this thesis, post-processing methods for motion artifact suppression in magnetic resonance imaging (MRI) are investigated. Based on experimental observations, a generalized motion model is empirically proposed. The non-rigidity or spatially variant characteristics of motions are taken into account by introducing a distortion transfer function (DTF). A techniques to estimate DTFs directly from corrupted images is developed. With DTFs identified, a composite image processing method is proposed to correct ghost artifacts caused by non-rigid periodic motions along the slice selection axis. There are several image processing tasks involved in this composite method, including contour detection and countour-based region labeling. It is proposed that contour detection is done by a new technique: the snake. The generalized motion model and the composite image processing method are demonstrated for both phantom images and an abdomen image with unknown respiratory motion.

University of Manitoba

New Preprocessing Methods For Better Classification Of MR And IR Spectra (Magnetic Resonance Spectra, Infrared, Genetic Algorithms)

Nikouline, Alexandre, PhD; Adviser: Somorjai, R. L.

We introduce a global feature extraction method specifically designed to preprocess magnetic resonance spectra of biomedical origin. Such preprocessing is essential for the accurate and reliable classification of diseases or disease stages manifest in the spectra. The new method is Genetic Algorithm-guided. It is compared with our enhanced version of the Forward Selection algorithm ('Dynamic Programming'). Both seek and select optimal spectral subregions. These subregions necessarily retain spectral information, thus aiding the eventual identification of the biochemistry of disease presence and progression. Both methods proved to be very useful for large datasets. The danger of overfitting related to the small number of samples in the datasets was demonstrated for both the artificial and real-life data. A bilinear regression model was used to quantitate the consequences of overfitting. Taking this in account, optimal parameters for the GA guided algorithm were recommended.

Infrared Spectroscopic Assessment Of Capillary-Alveolar Membrane Permeability In Acute Lung Injury: A Biophysical Perspective (Pulmonary Edema)

Wang, Jing, PhD; Adviser: Mantsch, H. H.

Increased permeability of the alveolar-capillary membrane results in diffuse alveolar damage that leads to non-cardiogenic low-pressure pulmonary edema. Clinically, this is referred to as acute lung injury (ALI). The well-described phenomenon of acute respiratory distress syndrome (ARDS) is a severe form of acute lung injury, often associated with a high mortality rate in the critical care population. Currently, there are very few practical techniques available to provide a rapid and direct measure of pulmonary microvascular permeability in the critical care setting. In this study, a novel diagnostic technique involving the administration of hydroxyethyl starches (HES) to patients with ALI/ARDS is introduced. The infrared (IR) spectroscopic determination of hydroxyethyl starch-based macromolecules in patient's bronchial washing fluids is used to assess the pulmonary alveolar-capillary permeability in acute lung injury. Hydroxyethyl starches are used clinically as colloid plasma expanders. The large size of infused HES, under normal circumstances, restricts these molecules to the intravascular space. Under conditions of increased pulmonary vascular permeability, high molecular weight fractions of the polymer with plasma protein components and water will leak into the pulmonary interstitium. The leakage of plasma protein and water result in pulmonary interstitial edema. IR spectroscopy and IR microscopy were applied to animal injury experiments for pulmonary permeability assessment. From the baseline study, two groups were recognized as "leak" and "non-leak" based on the spectral signature of HES in bronchial washing fluid. By applying a spectral pattern recognition methodology a training set was constructed based on a set of bronchial washings for leak and non-leak groups. Autopsy tissue from a patient with acute lung injury confirmed that investigation of a patient's bronchial washing fluid is able to provide an early diagnosis of ARDS. A prospective randomized study on an injured patient population was also conducted. The experimental and clinical investigations demonstrate that IR spectroscopy provides a direct measure of capillary-alveolar membrane permeability in acute lung injury. This technique is advantageous because no radioactive tracers are employed and little sample preparation is required. It is a rapid, simple, and a minimally invasive technique with high sensitivity for diagnosing ARDS. Furthermore, the assay method is very specific in evaluating pulmonary vascular permeability in acute lung injury cases. The simplicity of this method makes it convenient to use and applicable to the critical care environment. This study of the use of IR spectroscopy in the assessment of capillary-alveolar membrane permeability in acute lung injury patients represents a new and

significant application of this technique to clinical sciences. (Abstract shortened by UMI.)

University of Toronto

Detecting, Measuring And Imaging The Microcirculation With High-Frequency Doppler Ultrasound

Christopher, Donald Allan, PhD; Supervisor: Foster, Stuart

The microcirculation plays varied and critical roles in our general well being and defects in the microcirculation manifest themselves in many important disease states. In this thesis, the extension of Doppler ultrasound to the ultrasound frequency range 20-200 MHz is investigated as a non-invasive and quantitative technique for detecting, measuring and imaging the microcirculation. The theoretical advantages and limitations of high-frequency Doppler ultrasound (HFD) are discussed. Experimental continuous-wave and pulsed-wave HFD systems, which have been designed, constructed and optimised for detecting blood flow in the microcirculation, are described. Implementation of the systems at 40-MHz and 50-MHz in experimental investigations with phantoms show that HFD can detect and measure velocities on the order of the blood velocities found in the capillaries (0.5 mm/s) and arterioles (5 mm/s) with a suitable velocity resolution (30-200 μm/s), although the temporal resolution (150-500 ms) had to sacrificed slightly. *In vivo* experiments with a mouse ear model of the microcirculation demonstrate that HFD is capable of detecting and measuring blood velocities slower than 5 mm/s in arterioles of only 20 μm diameter and venules of only 35 μm diameter using a sample volume of only 70 μm laterally 150 μm axially. *In vivo* experiments using a rat mesentery model and intravital microscopy conclusively demonstrate that HFD can map the microcirculation in an arteriole bifurcation as well as detect the microcirculation in capillaries. The potential of high-frequency colour and power Doppler imaging is also demonstrated, and the two experimental systems are implemented in several preliminary biological and clinical investigations. This thesis has successively demonstrated that HFD is a unique and versatile technique with great potential as a tool for investigating the microcirculation in both clinical and laboratory settings.

A Feasibility Study of a Hybrid Photodiode Array – CCD as a Direct-Conversion X-ray Image Detector for Digital Mammography

Henry, Justin, MSc; Supervisor: Yaffe, M.

Early detection of breast cancer can potentially reduce both mortality and morbidity resulting from breast cancer. Because of certain technical limitations, film-screen mammography is not an optimal method for the detection of all types of breast cancer. This thesis is a study of a hybrid photodiode array – CCD, used as a direct-conversion x-ray image detector. Its feasibility as a digital mammography detector is investigated. Preliminary experimental results obtained from prototype devices are presented, and a detailed analysis is performed using a mathematical model of signal and noise propagation. The experimental and modeling results are used to optimize the photodiode and CCD design, and predict the performance of the proposed detector.

Site-Directed Cysteine Mutagenesis And Chemical Modification Of The High Affinity Na+/Glucose Transporter (SGLT1): Elucidation Of Structure/Function Relationships Underlying Na+ Permeation Through The Transporter (Sodium Transport)

Lo, Bryan, PhD; Adviser: Silverman, M.

Na+ cotransporters utilize the energy in the Na + electrochemical gradient to drive the transport of sugars, amino acids, and a variety of other substrates into cells. This coupling of Na + transport to the transport of another substance is a fundamental mechanism of energy transduction that has not been well defined at the molecular level. In this thesis, a combination of site-directed mutagenesis and voltage-clamp techniques is employed to identify structure-function relationships that underlie the binding of extracellular Na+ to the high affinity Na +/ glucose cotransporter (SGLT1) expressed in Xenopus laevis oocytes. Results from the chemical modification of cysteines engineered into SGLT1 indicate that certain residues in the region between putative transmembrane helices IV and V form the entrance to a Na+ -pore. Characterization of the steady-state and transient kinetics of another mutant in which a cysteine has replaced residue 156 in putative transmembrane helix IV suggests that this residue is located deep within this same Na+-pore. Together these results provide structural definition to the pathway that extracellular Na+ takes to its binding site in the SGLT1 transport protein.

Magnetic Resonance Imaging (MRI) Calorimetry for Tissue Ultrasound (US) Absorption Measurement

Wang, Yao, MSc; Supervisor: Plewes, Donald B.

The renewed interest in the use of high intensity focused ultrasound (US) for minimally invasive, MRI guided thermal therapy has stimulated a review of the interaction mechanisms of high intensity US with tissue. In particular, the variation of ultrasound absorption with frequency and temperature needs to be well understood to apply this technique optimally. While the study of US properties of tissues has been conducted extensively, agreement on the measured value of tissue US absorption are poor. Available data from various studies show as much as a four fold variation in the US absorption coefficient for the same frequency and tissue at room temperature. This is largely a result of experimental assumptions and the use of invasive thermocouples to measure tissue temperature elevation, which themselves, alter the heating and absorption properties of the tissue. A new appraoch to measure US tissue absorption has been studied here. It is based on a form of MRI calorimetry which allows non-invasive energy measurement. Validation data show excellent agreement of this method with the actual energy delivered. Calorimetry for US heating of freshly-excised bovine liver tissue sample has been conducted. This, together with hydrophone measurement of the incident US field, has led to a measured US absorption coefficient of 0.0581/*cm* or 9.504*dB/cm* (at 1 MHz and room temperature). As this appraoch can be applied over a range of frequencies, tissues and termperatures, it should provide a much improved means of measuring absolute tissue US absorption coefficients to improve US therapy planning, future transducer design and US dosimetry models.

University of Ottawa

Study Of Magnetic Field Effects On Radical Reactions And Of The Mobility Of Transients In Microheterogeneous Systems (Benzophenone, Free Radicals, Xanthone)

Mohtat, Nadereh, PhD; Adviser: Scaiano, J. C.

This thesis involves laser flash photolysis studies of the kinetic behaviour of photochemical reactions in heterogeneous media with the emphasis on the effects of magnetic fields on the reactions involving triplet radical pairs. Chapters 3 and 4 present results of the effects of magnetic fields on the behaviour of radical pairs in organized systems. Free radicals are known to be involved in many biological processes and are thought to be a major initiator of some types of cancer. As a result, we have determined how free radical behaviour is modified in

the presence of a 60 Hz oscillating magnetic field superimposed over a static magnetic field of comparable magnitude. We showed that the effect of an oscillating magnetic field on radical behaviour is identical to that exerted by a static magnetic field of the same strength provided the frequency is low in comparison with radical pair dynamics. We have used a test system involving radical pairs generated in micellar solutions by photolysis of benzophenone in the presence of 1,4-cyclohexadiene. Our results show that radical pair reactions in micellar solutions exhibit the same behaviour under 60 Hz oscillating fields as under static field conditions at any point in time. Given that (a) radicals play an important role in metabolic processes, and (b) that radical behaviour is strongly influenced by magnetic fields, it was clearly necessary to undertake experiments that better mimic in vivo systems. Laser flash photolysis of probe molecules, such as benzophenone and some of its derivatives, leads to a triplet spin-correlated radical pair due to the hydrogen abstraction of the triplet from Bovine and/or Human Serum Albumin. The analysis of the kinetics of the radical pair, where one of them is derived from the protein, in the presence and in the absence of a magnetic field, shows that the protein-probe radical pair is subject to a magnetic field effect. In Chapter 5, the photophysical properties of microheterogeneous systems have been characterized using the triplet state of an appropriate probe. (Abstract shortened by UMI.)

Performance Evaluation Of A Second-Generation Metaphase Finder For Chromosome-Based Radiation Dosimetry

Pollitt, David, MSc; Adviser: Rivest, J. F.; Gibbons, David T.

In this thesis an automated chromosome detection system will be described. The biological and clinical background for the need of such a system is presented with emphasis on cell biology. Work was done on three versions of the autofocusing algorithm as well as on two versions of the chromosome detection algorithm. Extensive testing was done to determine the best versions of these algorithms and additional program functionality was used to carry out this testing. The results of the testing on the autofocusing algorithms are presented in graphs that show a peak when the image is properly focused. The results of the testing and optimisation of the chromosome detection algorithms are displayed in Receiver Operating Characteristic curves. These curves allow the user to pick a point of algorithm functioning which yield an acceptable quantity of well formed chromosome spreads or True Positives along with a given proportion of poorly formed chromosome spreads or False Positives. The accuracy of the final algorithms are well within the desired limits.

University of Western Ontario

A Non-Invasive Diagnosis Of Malignant Hyperthermia Using Phosphorus-31 NMR Spectroscopy

Ahluwalia, Baldev Singh, MSc; Adviser: Thompson, R. T.

Malignant Hyperthermia (MH) is a potentially fatal skeletal muscle disorder induced by certain anaesthetics. The present method of diagnosis entails a six cm muscle biopsy and subsequent in vitro contracture tests. The purpose of this study was to develop a non-invasive test to diagnose MH based on differences in muscle metabolism exposed during an exercise protocol and monitored with phosphorus nuclear magnetic resonance spectroscopy (^{31}P MRS). Enrolled in this study were 11 controls (35 ± 3 years) and 25 MH susceptible patients diagnosed by muscle biopsy: 9 patients with an HCK-MH diagnosis (39 ± 4 years), and 16 from a less susceptible (mixed-MH) group (43 ± 3 years). The exercise test consisted of wrist flexion at a progressive work rate which continued to volitional fatigue, or when the phosphocreatine (PCr) concentration was reduced by 80% from resting values. The post exercise recovery kinetics of PCr and pH were modeled with a mono-exponential function and characterized by time constants τPCr and τpH respectively. The calculation for τpH started from the minimum value of pH post cessation of exercise with the delay noted as the pH lag time. The HCK-MH group had a longer pH lag time than controls (69 ± seconds verses 45 ± 6 seconds, $p < 0.05$), and a longer τPCr (162 ± 14 seconds verses 94 ± 5 seconds, $p < 0.05$) when corrected for end exercise pH. There were no significant differences between the less severe MH group and controls during recovery. Discriminant analysis between the HCK and control subjects lead to complete delineation between the groups (ANOVA, $p < 0.001$). The use of ^{31}P MRS as a screening tool for MH susceptibility could reduce the number of patients who require a muscle biopsy and thus decrease the morbidity associated with diagnosing the disease.

All-Metal Glenoid Component Design In Shoulder Arthroplasty: An In Vitro Implant Stability Study

Bicknell, Ryan, MSc; Adviser: Johnson, J. A.

A prototypal stainless steel cross-keeled glenoid component was designed and implanted in ten cadaveric scapulae. A pneumatic testing apparatus was employed to test implant stability utilizing four Linear Variable Differential Transducers, or LVDTs, to measure implant micromotion relative to the bone. Testing variables included six directions and three angles of load application, three component thicknesses, and six fixation modalities--unkeeled, small, medium and large cross-keels, supplemental screws and bone cement. The component displayed a consistent response to loading, with compression at the side of load application and distraction at the contralateral side, characteristic of a rigid body on an elastic medium. The presence of any type of fixation resulted in greater stability when compared with the unkeeled component. The use of screw and cement fixation resulted in the most stable fixation of the methods investigated($p < 0.05$). Greater stability was found with decreasing component thickness ($p < 0.05$) and decreasing angle of load application ($p < 0.05$). Both these results can, in all likelihood, be attributed to the change in the resultant load vector, or the line of action of the joint load. With micromotion measurements in the range of 60 to 80 micrometres, this prototypal stainless steel cross-keeled glenoid component demonstrated increased stability over previous studies of polyethylene components.

Small Vessel Imaging Using 3-Dimensional Power Doppler Ultrasound

Boksman, Laura, MSc; Adviser: Fenster, Aaron

The ability of 3-D power Doppler ultrasound to detect small blood vessels was examined by obtaining a 3-D ultrasound image from a rabbit kidney which was then surgically resected, injected with thick barium, sectioned, radiographed, and made into microscope slides. Planes of the 3-D ultrasound image were compared to the slides of two kidney sections where cortical arterioles were measured. Using linear regression and correlation analysis of square regions 0.85 mm wide, radiographs of four kidney sections were compared to the corresponding sections in the 3-D ultrasound image. In regions where the 3-D power Doppler ultrasound image detected cortical blood flow, the diameter of interlobular arterioles ranged from 7 to 200 μm, the size of many angiogenic breast cancer vessels. After accounting for blood vessels perpendicular to the ultrasound beam, good agreement was found between the radiographic and ultrasound images, with a correlation coefficient of 0.685.

Changes In Cerebral Blood Volume And Blood Flow In Brain Tumours During Propofol Or Isoflurane Anaesthesia And Hyperventilation

Cenic, Aleksa, MSc; Adviser: Lee, Ting-Yim

The effect of hyperventilation on regional cerebral blood volume (CBV) and blood flow (CBF) during Propofol or Isoflurane anaesthesia in brain tumour rabbits was examined. CBV was measured using a previously developed contrast enhanced CT method, while CBF measurements were simultaneously acquired using microspheres. During Propofol, hyperventilation induced a significant decrease in CBV (10%) and CBF (18%) in only the peri-tumour region. During Isoflurane, hyperventilation induced a significant global decrease in CBV (13 ± 3%), but no significant decrease in CBF except in the contra-lateral temporal region (28%). This thesis also presents the validation of a method to measure regional CBF using contrast enhanced CT through the application of the Central Volume Principle and the technique of deconvolution. Regional CT CBF measurements were compared to those simultaneously obtained with the 'gold' standard microsphere method in rabbits under normal conditions. A strong correlation was found between rCBF values derived by the CT and microsphere methods ($r = 0.835$).

Resolution-Dependent Estimates Of Multiple Sclerosis Lesion Loads: Evaluation Of Magnetic Resonance Imaging Of The Brain At 4 Tesla Versus 0.5 And 1.5 Tesla

Erskine, Matthew Kelly, MSc; Adviser: Karlik, Stephen J.

Changes in brain lesion loads assessed with magnetic resonance imaging (MRI) scans, usually obtained at 0.5 or 1.5 T, are used as a measure of disease evolution in virtually all long-term natural history studies and treatment trials of multiple sclerosis. In this study, a comparison was made between the total lesion volume and individual lesions observed in typical 'clinical trial' 0.5 and 1.5 T MRI scans versus high-resolution 4 T scans, representing the highest quality imaging achievable in a clinically reasonable timeframe using current technology. Lesions were quantified in 14 patients using a computer-assisted segmentation tool. The 4 T scans showed an 85% increase in total lesion volume when compared with the 0.5/1.5 T scans ($n = 14$, $r = 0.875$, $p < 0.001$). In several instances, the 0.5/1.5 T scans showed individual lesions that coalesced into larger areas of abnormality in the 4 T scans. When individual lesions were directly compared ($n = 378$), 49% of those seen at 4 T were not detected at 0.5/1.5 T. These lesions were small with an average volume of 0.061 ± 0.008 cm^3 (range: 0.004 to 0.941 cm^3) and accounted for approximately 6% of the total 4 T lesion volume. This enabled the acquisition of images with improved in-plane and out-of-plane resolution, resulting in substantially increased lesion detectability at 4 T. (Abstract shortened by UMI.)

The Effects Of Sampling, Reconstruction, And T(2) Modulation For Polar K-Space Acquisitions In Magnetic Resonance Imaging (Image Reconstruction)

Lauzon, Michel Louis, PhD; Adviser: Rutt, Brian K.

Magnetic resonance imaging is a powerful imaging modality whereby tissue can be characterized according to various contrast mechanisms, most notably T_2-weighted contrast. The T_2-weighted images are very useful clinically, but the major disadvantage is that these high-quality images often require long imaging times. The Cartesian RARE-mode acquisition proposed by Hennig retains the soft-tissue contrast-to-noise ratio (CNR) and signal-to-noise ratio (SNR) of conventional T_2-weighted images, but at a reduced acquisition time. Moreover, non-Cartesian sampling schemes offer further advantages in motion and flow artifact suppression, and efficient use of gradients. In this treatise, the viability of T_2-weighted polar k-space sampling acquisitions is assessed and compared for projection reconstruction (PR-MRI) and concentric circles (CC-MRI). We analyze the fundamental aspects including sampling and image reconstruction effects such as aliasing, resolution, and SNR, and we investigate the T_2-weighting contrast of PR-MRI and CC-M RI when imaging in RARE-mode. The Fourier aliasing effects of uniform polar sampling are explained from the 2D principal point spread function (PSF). This is determined by assuming equally-spaced concentric rings in k-space. The 2D polar effects such as replication, smearing, truncation artifacts, and sampling requirements are characterized. Although the 2D polar sampling PSF leads to some subtle aliasing effects and artifacts, these effects can be suppressed depending on the choice of reconstruction algorithm one uses. For uniform polar sampling, both gridding (GRD) and convolution backprojection (CBP) are applicable. The respective strengths and weaknesses of these algorithms are analyzed, compared, and discussed. Provided that the image resolution and the SNR are considered together, these algorithms perform similarly. But, their aliasing behaviour is different because GRD is a 2D Fourier inversion algorithm, whereas CBP is based upon a 1D Fourier inversion. The effective echo times (TE) and resulting T_2 contrast curves of RARE-mode PR-MRI and CC-MRI are derived. The effective TE of RARE-mode PR-MRI is shown to be highly dependent on T_2, the echo spacing (ESP), and the echo train length (ETL). By comparison, the effective TE of RARE-mode CC-MRI is not nearly as sensitive to ESP and ETL, especially for large objects within the field of view. Finally, we propose a novel yet general method of correcting for the T_2 modulation effects of RARE-mode sequences to allow the acquisition of high SNR, high CNR, properly T_2-weighted images.

Onset Of BOLD fMRI Response Correlates With Visuomotor Reaction Time

Luknowsky, David, MSc; Adviser: Menon, Ravi S.

Presented here are the results of functional magnetic resonance imaging of motor and visual cortical areas performed at 4 Tesla. Subjects executed a cued, visually guided motor task. Activation was detected in the primary motor cortex, the supplementary motor area, the premotor cortex, the somatic-sensory cortex, the posterior parietal cortex, the primary visual cortex, and the middle temporal area. A method for measuring the time interval between onset of the average blood oxygenation level dependent response in the primary visual and motor cortices is proffered. On average, the measured time interval was shown to correlate with the kinematically measured visuomotor reaction time. The same method was used to measure delays in primary visual cortex of each hemisphere in an experiment where there were known delays between half-field visual stimuli. The measured time interval is shown to correlate with stimulus lag over a range of delays from 0-1000 ms.

Magnetic Resonance Imaging Developments For The Study Of Breast Tumour Microvasculature (Noninvasive Surgery)

Maier, Cynthia F., PhD; Adviser: Rutt, Brian K.

The development of noninvasive methods for characterizing mammographically indeterminate lesions represents an active area of current research in medical imaging. In particular, much research effort is being directed toward the development of new techniques for measuring tumour blood flow. This thesis consists of experiments designed to evaluate the use of a magnetic resonance imaging technique called Intravoxel Incoherent Motion (IVIM) to produce microvascular flow images of breast lesions. The first phase of this thesis addresses the underlying biological question of whether malignancies can be distinguished from benign lesions on the basis of microvessel density. Histological techniques were used to stain for blood vessels on archival breast biopsy tissue. Vessel distributions in invasive carcinomas were compared to those in fibroadenomas, a class of commonly occurring benign lesion. There was no significant difference in numbers of microvessels between the fibroadenomas and carcinomas in our study; however, vessels were concentrated around the boundaries of invasive carcinomas, whereas, in fibroadenomas, they were more uniformly distributed. A second major focus of this thesis is the evaluation of IVIM in an animal tumour model. Quantitative diffusion measurements using the gold-standard Pulsed Gradient Spin Echo (PGSE) sequence were performed. Measured diffusion coefficients were specific for viable and for necrotic tumour in our model. These results show promise for

using diffusion-weighted imaging to noninvasively follow tumour response to therapy. However, further studies using the PGSE technique revealed that the high sensitivity of this sequence to macroscopic motions such as patient respiratory motion will likely prevent its use for IVIM measurements of tumour blood flow in vivo. The third phase of the thesis was the design and construction of a breast gradient coil set to be used as a hardware add-on for a clinical MR scanner. The high gradient efficiencies of these coils will provide images with better spatial resolution than can currently be achieved clinically, and additionally, will provide large motion-sensitizing gradients that facilitate diffusion and flow imaging. Moreover, the availability of large readout gradients enables imaging using fast, motion-insensitive techniques such as echo-planar imaging.

Measurement Of Renal Blood Flow In Normal And Obstructed Kidney Using Dynamic Contrast Enhanced X-Ray Computed Tomography

Mosalaei, Homeira, MSc; Adviser: Lee, Ting-Yim

We have developed a dynamic contrast enhanced X-ray CT method to measure renal blood flow (RBF), extraction efficiency of glomerular filtration rate of the CT contrast material (EE), mean transit time of the kidney (MTT) and renal blood volume (RBV), all in a single study. Serial contrast enhanced CT abdominal scans were acquired after intravenous injection of contrast material, to measure the contrast concentration in the kidney (C(t)) as well as arterial concentration (A(t)). Using a 'robust deconvolution algorithm', above-mentioned curves were deconvolved and the impulse residue function (IRF) of the kidney was obtained. Using the Central Volume Principle (Meier and Zieler 1954), all the physiological variables: EE, MTT, RBV and RBF were then extracted from IRF. Precision and sensitivity tests were done to evaluate the deconvolution algorithm. Those tests revealed that our algorithm is able to calculate RBF and EE as well as other related parameters, MTT and RBV, within 90% confidence limit. In addition, the changes in EE, MTT, BV and BF were investigated after creating acute and chronic ureteropelvic junction obstruction (UPJO). Acute hydronephrotic kidney showed 30-50% decrease in BF and 10-20% increase in EE. Chronic hydronephrotic kidney showed 40-50% decrease in BF and 10-20% increase in EE. Comparing before and after obstruction results in contralateral kidney, demonstrate that our technique is capable to detect small changes (as low as 3%) in RBF and EE.

Feasibility Of ECG Gated Cardiac Computed Tomography

Nolan, Jennifer, MSc; Adviser: Cunningham, Ian A.

Conventional Computed Tomography (CT) is of limited use for imaging the heart due to motion artefacts. An ECG gating technique to suppress these artefacts has been developed. The technique involves acquiring data during approximately 16 consecutive 1-second gantry rotations, and selecting data retrospectively to reconstruct images for desired cardiac phases. This concept was verified and evaluated through a motion phantom experiment. The results indicated that the visible distortion in the image is removed when the rms variation in cardiac phase among the selected projections $\Delta\tau_{rms}$) is less than 20 ms. A numerical analysis of ECG wave-forms indicated that it is feasible to attain $\Delta\tau_{rms} < 20$ ms for 87% of real patients, and $\Delta\tau_{rms} < 22.5$ ms for all patients, if two scanning periods are made available on the scanners. Suggestions for clinical implementation of ECG gated CT are made. If implemented, it may become a useful and relatively inexpensive tool in diagnostic cardiology.

The Determination Of Myocardial Viability Using Magnetic Resonance Imaging And Gd-DTPA (Infarcted Tissue, Occluded Arteries, Coronary)

Pereira, Raoul Sanjay, PhD; Adviser: Prato, Frank S.

The non-invasive discrimination of viable from infarcted tissue after a heart attack is crucial for the proper management of patients. Recently, due to the use of new and effective therapies to restore flow to secluded coronary arteries, this has become even more important. Currently used imaging techniques lack the spatial resolution and/or specificity to accurately assess the extent of permanent tissue damage. It was postulated that the distribution volume (λ) of an extracellular MRI contrast agent (Gd-DTPA) would significantly increase in infarcted tissue due to damage of the myocyte cell membrane. Using an animal model of ischaemia-reperfusion injury it was established that: (i) 3λ was inversely related to myocardial viability, ie: λ was greater in infarcted tissue with cell membrane damage; (ii) λ was increased in damaged tissue as early as 1 minute to as late as 8 weeks post reperfusion; (iii) λ could be accurately estimated in vivo using MR image signal intensities. This allowed us to follow λ in vivo. Previously, we determined λ using radioactive counting of ^{111}In-DTPA in excised tissue sections and blood samples. Further, using an animal model of sustained coronary artery occlusion (without reperfusion) it was established that: (i) λ was increased in damaged tissue as early as 2 days post occlusion and may have been increased as early as 4 hours post occlusion. Based on these encouraging results a limited clinical trial comparing contrast-enhanced MRI with rest-redistribution ^{201}Tl SPECT and dobutamine stress testing with cine MRI functional assessment was performed. Analysis of the first 7 patients has established that: (i) increased signal intensity on MR images during a constant infusion of Gd-DTPA was indicative of infarcted tissue as determined by regions of decreased signal on ^{201}Tl SPECT images; (ii) myocardial tissue with increased signal intensity failed to show increases in contractility with dobutamine, again indicating that these regions represent infarcted tissue; (iii) values of λ in damaged and normal tissue calculated in vivo were similar to those obtained in the animal studies. Although additional animal and human work is needed to establish the relationship of increased distribution volume and myocardial tissue viability under all possible tissue states following ischemic injury, MRI with Gd-DTPA shows great promise in the non-invasive determination of myocardial viability.

Blood Flow Visualization And Flow Rate Estimation With Colour Doppler Ultrasound

Picot, Paul, PhD; Adviser: Fenster, Aaron

Flow measurements in blood vessels help evaluate: arteriovenous shunts for dialysis patients; the health of transplanted organs such as kidneys; the efficacy of angioplasty or stents procedures; shunts or bypass operations; and fetal health. Flow measurements may also help evaluate the risk for stroke. Measurement of blood flow using Doppler ultrasound (measurement of frequency shifts produced by moving tissue) has been used clinically and in research since the 1960s. Recent developments of high-performance ultrasound transducers, colour Doppler imaging, and fast digital computers allow new techniques for the measurement and visualization of blood flow. This thesis describes the development and characterization of two such techniques: three-dimensional flow visualization; and quantitative volume flow estimation. A system was developed to acquire three-dimensional ultrasound images of blood flow in-vivo. Typically 64 consecutive 2-dimensional images were acquired in synchrony with the cardiac cycle and reconstructed into a 3D image approximately 37 x 25 x 25 mm^3. The 3D image represented the blood velocities (Doppler shifts) in a colour scale, and could be interactively manipulated to yield the best view of the blood flow image. The system was characterized with respect to geometrical, temporal, and velocity accuracy. Good cardiac gating precision was required, and 1.5 ms was sufficient for carotid imaging. Two techniques for flow estimation were evaluated. The first, based on one-dimensional velocity profiles along a vessel diameter, was evaluated numerically and in-vitro with respect to the effect of ultrasound beam width, blood vessel size, beam-to-vessel alignment, and vessel ellipticity. Beam-to-vessel alignment was found to be critical. Measurements

varied by 5% per degree uncertainty on Doppler angle. A second, new, flow estimation technique using 2-D velocity profiles was developed and a system using this technique was constructed. Effects from Doppler angle uncertainty, signal power uncertainty, vessel size, flow frequency content, and video-format acquisition were evaluated. Measurement uncertainty increased markedly in blood vessels smaller than 2 mm. Video data acquisition was not suitable for measuring pulsatile flow, but implementation of the algorithm using digital data within the ultrasound system exhibited good performance with sample rates above 20 Hz. Measurements varied by 4% per degree uncertainty in Doppler angle.

The Elastin And Collagen Microstructure Of Aortic Heart Valve Cusps

Scott, Michael, PhD; Adviser: Vesely, Ivan

The aortic valve is of interest because of its propensity to become diseased and porcine xenograft valves are used as prosthetic replacements. Despite knowledge of the gross anatomy and mechanical properties of the aortic valve cusp, little of the detailed morphology of its structural components and how they contribute to the observed mechanics is known. The highly non-linear, anisotropic mechanics exhibited by the cusp imply a specialized underlying structure. To explain how the cusp deforms to carry loading and why it functions so well in situ, this work studies the quantities, locations and organization of the structural connective tissue proteins collagen and elastin in porcine aortic valve cusps. Protein content of the layers within porcine cusps were measured. Collagen comprises 53.6% ± 8.9 of the fibrosa, 21.5% ± 5.2 of the spongiosa and 56.8% ± 8.7 of the ventricularis. Elastin comprises 10.5% ± 3.3 of the fibrosa and 21.4% ± 3.0 of the ventricularis. No difference was found between the protein content of the coaptation region and fibrosa. Overall, the cusp contains 45.4% ± 5.1 collagen and 13.3% ± 2.1 elastin. Elastin was isolated from porcine cusps and imaged using scanning electron microscopy to identify structures in the fibrosa and ventricularis. Amorphous sheet structures and a variety of fibrous meshes were identified. The ventricularis contains large continuous in-plane sheets of elastin while fibrosa elastin forms a complex system of voids that are directed from the line of attachment towards the Nodulus Arantii. Transmission electron microscopy (TEM), and light microscopy (LM) with three-dimensional computer reconstruction were used to validate these results. Polarized LM and TEM showed that collagen in the ventricularis consists of layers of alternating principal orientation. Large bundles enter the fibrosa along the aortic attachment, oriented towards the Nodulus Arantii, before branching into smaller bundles towards the middle. The porcine aortic valve cusp is a complex composite, layered structure. Collagen is surrounded by an elastin matrix of discrete fibrous and continuous amorphous components. The collagen and elastin model presented is consistent with observational and mechanical test results of many researchers. These proteins interact such that their mechanics are complementary, providing the unique mechanics and durability exhibited by this tissue.

Efficacy Of Diaspirin Crosslinked Hemoglobin (Dclhb) Transfusion In Oxygen(2) Supply-Dependent Septic Rats

Sielenkamper, Andreas, MSc; Adviser: Sibbald, W. J.

The efficacy of Diaspirin crosslinked hemoglobin (DCLHb) in sepsis was studied by comparing its effect on systemic O_2 uptake to freshly stored and aged red blood cells (RBCs) in septic rats. 24 hours after induction of sepsis, O_2 supply-dependency (OSD) was created by isovolemic hemodilution. Rats were randomized to receive an exchange transfusion of 7.5 ml 'fresh' RBCs (stored < 6 d, Hct 70%), 'fresh' diluted RBCs (stored < 6 d, Hct 30%), 'old' RBCs (stored 28-35 d, Hct 70%) or DCLHb (Hb 100 g/l). Survival following OSD and transfusion with old RBCs was poor (33% vs. 91.7% in the other groups, $p < 0.01$), precluding further analysis of post-transfusion data from this group. Systemic O_2 uptake increased in all remaining groups ($p < 0.001$), while arterial lactates fell. Systemic O_2 delivery increased with 'fresh' RBCs ($p < 0.0001$) and 'fresh' diluted RBCs ($p < 0.05$), but not with DCLHb. Systemic O_2 extraction increased with DCLHb as compared to baseline ($p < 0.05$) and to the other groups ($p < 0.0001$). DCLHb or 'fresh' RBC infusion was efficacious at increasing systemic O_2 uptake in O_2 supply-dependent, septic rats.

Geometric Models Of The Stenosed Human Carotid Bifurcation

Smith, Robert, MSc; Adviser: Holdsworth, David

Atherosclerotic lesions are commonly localized in specific regions of the vasculature. Lesions commonly develop at the carotid bifurcation. Advanced internal carotid artery lesions are of particular interest because there is a correlation between the measured reduction in lumen diameter, and the treatment protocol to minimize the risk of stroke. A method to characterize the geometry of the stenotic carotid bifurcation was developed, since there was no pre-existing patient-based model. Average geometrical representations of the bifurcation for several stenosis grades were determined by analyzing digitized x-ray angiograms from 62 symptomatic patients. Bifurcation geometries for normal (disease-free), 30%, 50%, 60%, 70%, and 80% diameter reduction were developed. A lost-material fabrication technique to produce polyester plastic and agar gel models of the stenotic bifurcation geometries was developed. The fabrication technique permitted production of flow-through vascular models in the geometries determined by analysis of the patient data. The models were found to be compatible with magnetic resonance (MR), x-ray, and ultrasound techniques. The utility of the phantoms was demonstrated by evaluating the relative sensitivity and specificity of three MR angiography techniques that can be used clinically in the assessment of carotid atherosclerosis. (Abstract shortened by UMI.)

An In Vivo Study Of Angiogenesis In A Brain Tumour Model By Dynamic Contrast-Enhanced CT Scanning

Stevens, Laura, MSc; Adviser: Lee, Ting-Yim

After radiation therapy of a tumour, a major problem in diagnostic radiology is the differentiation of necrotic tissue and recurring tumour. Measurement of cerebral vascular volume (V_v) and blood-brain barrier permeability (K) can make this distinction as both will be elevated in a recurring tumour but V_v is expected to be reduced in necrotic tissue. We have developed a contrast-enhanced CT method to measure these parameters in a rabbit brain tumour model. VX2 carcinoma cells were injected into the right parietal lobe of 2-3 kg male New Zealand White rabbits. Before sacrifice, 1 to 4 serial CT studies were performed every 2 days starting 7 days after implantation. K and V_v were shown to rise with increasing tumour volume. Necessary hardware and procedures were developed to perform a 20Gy stereotactic radiosurgery (SR) and preliminary experiments examined the efficacy of measuring the effect of SR on K and V_v.

Modelling Water Transport In The Brain For Measuring Cerebral Blood Flow: A Study Using Deuterated Water And Magnetic Resonance Spectroscopy

St. Lawrence, Keith S., PhD; Adviser: Lee, Ting-Yim

Cerebral blood flow can be measured by modelling the clearance of labelled water from brain tissue. A limitation to using labelled water as a tracer is that the estimate of CBF, determined using the Kety model, is dependent on the length of time that the clearance data is collected (the falling flow phenomenon, FFP). A more realistic model is the tissue homogeneity (TH) model and we have derived a simplified time domain solution to this model using the adiabatic approximation. The adiabatic solution accounts for the rapid removal of water from the capillaries and the clearance of water that was extracted into tissue.

CBF was measured in rabbits using magnetic resonance spectroscopy with a surface coil to acquire the D_2O clearance data. By analysing the data with the adiabatic solution, the FFP, observed with the Kety model, was eliminated. For validation, CBF was also measured using microspheres and these measurements were compared to those obtained from the D_2O clearance data. It was shown that the adiabatic solution could accurately measure CBF up to 60 ml 100 g^{-1} min^{-1}. Above this value the limited extraction of water into tissue resulted in an underestimation of CBF. To determine CBF in a defined region of interest (ROI), a spatial localisation technique was developed that is suitable for use with D_2O. This technique used projection presaturation to eliminate the signal in the volume surrounding the ROI, followed by a two-dimensional pulse to excite the ROI. As demonstrated in studies using phantoms filled with either water and D_2O and in-vivo, combining these two techniques significantly reduced the signal contamination from outside the R_2O compared to when either technique was applied separately. CBF was measured in rabbits using the localisation sequence to obtain the D_2O clearance data from a defined ROI. As before, CBF was also measured using microspheres. The correlation between the measurements from the microspheres and from the D_2O clearance data demonstrated that CBF can be measured in a specified ROI by using the proposed localisation sequence and using the adiabatic solution to model the D_2O clearance data.

Coherent-Scatter Computed Tomography (Bone Mineral Content, Imaging, Osteoporosis)

Westmore, Michael, PhD; Adviser: Cunningham, Ian A.

Low-angle scatter of x rays at diagnostic energies is primarily coherent. This coherence gives rise to interference, resulting in x-ray diffraction patterns that are characteristic of the scattering material. A method is described of imaging these low-angle (0-10°) x-ray diffraction properties of media using a diagnostic x-ray beam and image intensifier-based system as a means of producing diagnostically relevant information on biological materials. It is shown theoretically that measurements made with this system can be expressed as the mono-energetic cross section 'blurred' by x-ray spectrum using a linear superposition integral. Experimental results using aluminum powder confirm this. In spite of this blur, measurements with this system of materials such as water, Lucite, and hydroxyapatite are significantly different. This method has been combined with computed tomography (CT) principles to develop a special-purpose CT system which produces images based on the x-ray diffraction properties of an object. First-generation CT geometry is used to acquire a diffraction pattern for each pencil-beam. A series of images is reconstructed to represent the scatter intensity at a series of scatter angles. The potential of coherent-scatter CT (CSCT) is illustrated by a sequence of images of a phantom consisting of water-filled Lucite cylinder containing rods of polyethylene, Lucite, polycarbonate, and nylon. Cross sections are generated for each pixel from this sequence of images and basis-function analysis is used to generate material-specific images which show excellent agreement with the known phantom makeup. The accuracy of quantitative, material-specific measurements made with coherently-scattered x rays has been examined using step wedges of SB3 (a bone mimic), AP6 (an adipose-tissue mimic), and Lucite. Coherent-scatter diffraction patterns were acquired of these materials in different combinations and thicknesses. Basis functions were measured and used to determine the thickness of each material present in each combination. The results show that CSCT has the potential to make quantitative, material-specific density measurements in tomographic images, in particular measurements of bone-mineral content (BMC) in bone samples and in patients.

New Products

Mentor Canada – IoGold Seeds

For prostate brachytherapy treatment, Mentor Medical Systems offers IoGold(tm) Iodine-125 radioactive sources. IoGold(tm) radioactive sources are designed to be permanently implanted into the prostate gland as a treatment option for prostate cancer. These radiation seeds consist of laser welded Titanium capsules containing Iodine-125 radioactive material. IoGold(tm) implants feature gold markers that provide high contrast under x-ray and fluoroscopy for excellent visualization of seed location. The IoGold(tm) radioactive source is certified by The National Institute of Technology, NIST and the Task Group 43 data was published in Medical Physics Journal, September 1999 issue. Mentor Medical Systems also offers clear and metal hubbed needles for prostate brachytherapy along with preloaded Mick cartridges. For further information on our IoGold(tm) radioactive sources or any of our brachytherapy products, call Mentor at 1-800-668-6069 or fax us at (905) 725-7340.

PIPSpro version 3.2

Masthead Imaging releases PIPSpro version 3.2

Masthead Imaging has released a 32-bit version of the popular PIPSpro portal imaging software. This new release is fully compatible with long directory and file names, which is particularly important for users of the Eliav PORTpro and the Siemens BeamViewPLUS portal imaging devices. With almost 100 installations in 22 countries, the "PIPS family" has accumulated a wealth of experience in portal image processing and analysis, and PIPSpro version 3.2 incorporates many features suggested by users from their own clinical practice. Further details are available at http://go-pips.com.

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President

McMaster University

Medical Physics - tenure track appointment

McMaster University invites applications for a tenure-track appointment in the Medical Physics and Applied Radiation Sciences Unit of the Department of Physics & Astronomy. The position is to begin on 1st July, 2000, or as soon thereafter as possible. Candidates should possess a PhD and have demonstrated both an excellent research record and an aptitude to teach. The ideal candidate will possess core strengths in the fundamentals of medical imaging. She/he would be expected to contribute particularly to the graduate programmes in Health & Radiation Physics and Medical Physics through mounting one or more courses, attracting research funding and mentoring graduate students. There would also be some expectation that the person appointed would contribute to undergraduate education through, for example, the Honours Medical and Health Physics or other Physics programmes.

McMaster has been successful in winning investment from the Canadian Foundation for Innovation and the Ontario Innovation Trust to the Medical Physics and Applied Radiation Sciences area. The University itself has supported these initiatives through the creation of this Unit and the creation of a research Institute of Applied Radiation Sciences, as well as through financial investment. This has built on strong, long standing partnerships with Hamilton Health Sciences Corporation and Cancer Care Ontario in bringing together research and education in Medical Physics. The successful candidate for this position will join an enthusiastic, multidisciplinary, multi-institutional team that is looking forward to capitalizing on its recent success to build further opportunities in the future.

Existing research fields within the Medical Physics and Applied Radiation Sciences Unit include laser and light propagation in tissue for photodynamic therapy and tissue characterization; the cellular and molecular basis of photodynamic therapy; the role of DNA damage and DNA repair processes in carcinogenesis and in the response of tumour cells to radiotherapy and chemotherapy; novel methods of imaging bone architecture and joint structure non-invasively; dosimetry of diagnostic and brachytherapy radioisotopes; imaging in PET and MRI, particularly for neurological and cardiac studies; and nuclear and atomic techniques used for body composition studies. McMaster has major facilities for Radiation Science research, including a nuclear reactor, an accelerator laboratory and a cyclotron used for production of PET isotopes. Candidates should consider how they would interact with and extend existing research and be able to exploit facilities.

In accordance with Canadian immigration requirements, this advertisement is directed to Canadian citizens and permanent residents. McMaster University is committed to employment equity and encourages applications from all qualified candidates including aboriginal peoples, persons with disabilities, members of visible minorities, and women.

Applications, including a statement of research interests and letters from three referees should be sent by March 31st, 2000 to Dr. D.R. Chettle, Medical Physics and Applied Radiation Sciences Unit, Department of Physics & Astronomy, McMaster University, Hamilton, Ontario, L8S 4K1, Canada. Telephone (1) 905 525 9140 ext 27340, FAX (1) 905 528 4339, e-mail: chettle@mcmaster.ca.

MEDICAL PHYSICS DEPARTMENT
KINGSTON REGIONAL CANCER CENTRE
KINGSTON, ONTARIO
CANCER CARE ONTARIO

TWO MEDICAL PHYSICS POSITIONS

Applications are invited for two positions in the Medical Physics Department of the Kingston Regional Cancer Centre (KRCC):

1) **a full time Medical Physicist**, and
2) **a Medical Physics Resident**.

The Centre is one of eight regional cancer centres operated by Cancer Care Ontario and is located at the Kingston General Hospital, on the campus of Queen's University. Cancer Care Ontario through its regional centres and partnerships, provides a province wide system of cancer care in Ontario, Canada. Approximately 2,000 new cancer patients are registered annually at the Centre. The Radiation Oncology Programme operates one Clinac 600C and two Varian Clinac 2100C/D linacs, a cobalt unit, an orthovoltage unit, an LDR afterloading unit, and a Theraplan Plus 3D treatment planning system. Members of the Medical Physics Department supervise medical physics graduate students in the Department of Physics at Queens University.

The successful Medical Physicist candidate will be expected to participate in all clinical, educational and research activities of the Medical Physics Department. Clinical activities include acceptance testing and commissioning of new equipment, calibration, dosimetry data base maintenance, quality assurance, and treatment planning support. All medical physicists are expected to be active leaders in the development of technical improvements in the radiation planning and treatment program. The Medical Physics Resident will receive clinical training over two years with the goal of successful completion of the requirements for Peer Review A within CCO. About one fifth of the resident's time will be devoted to research.

Physicist candidates must be fully trained Medical Physicists, with a postgraduate degree and a minimum of three years of post-training experience in clinical radiation therapy physics. Membership in the Canadian College of Physicists in Medicine or equivalent certification is preferred. Applicants should have good evidence of research and/or development activity, with credentials and experience which could lead to an academic appointment in the Physics Department at Queen's University. Experience with 3D planning, Monte Carlo computer simulation and expertise in networking and administering computer systems would be an asset. Qualifications for the residency position include a graduate degree in medical physics, preferably a Ph.D.

Applications are invited from all qualified candidates; please indicate which position is being applied for. Priority will be given to Canadian citizens and permanent residents of Canada, in accordance with Canadian Immigration requirements. Please submit curriculum vitae and the names of three professional referees by 15th February 2000 to:

L. John Schreiner, Ph.D., FCCPM
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MEDICAL PHYSICIST POSITION

CHVO Gatineau, Québec, Canada
October 27, 1999

The Centre Hospitalier des Vallées de l'Outaouais has an immediate opening for a full time clinical medical physicist. The responsibilities for this position include the support of radiation oncology and medical imaging.

The radiation oncology department is equipped with two Siemens Mevatron dual energy linear accelerators, a Nucletron microSelectron HDR remote afterloading system, a Therapax 300 orthovoltage unit, and a Simview 3000 simulator with CT attachment. External beam treatment planning is performed on a Theraplan Plus treatment planning system, while brachytherapy planning is performed on a Plato BPS workstation. Physics tools include a Wellhofer water tank radiation field analyser, film scanner and MOSFET in-vivo detectors.

The medical physics department will be strongly implicated in several upcoming projects. In the year 2000, low dose rate (LDR) brachytherapy will be commissioned. As well, funding for a new MRI machine has been approved, and the equipment will be purchased next year. The medical physics department will be instrumental in the selection, commissioning, and maintenance of this equipment. Finally, the radiation oncology department is in the preliminary stages of a proposed expansion. This will include the purchase of two new linear accelerators, a CT simulator, and the addition of a physics laboratory, machine shop and electronics shop.

The CHVO is comprised of two hospitals located in Gatineau and Hull, Québec. Being at the centre of the National Capital Region, we offer a high standard of living due to our close proximity to a wide range of parks, museums, bicycle paths, universities and recreational facilities.

The Centre Hospitalier des Vallées de I'Outaouais is searching for motivated physicists who welcome the opportunity to fully participate in all aspects of a growing medical physics department. We encourage and expect the active participation of all physicists in all aspects of our department. The successful candidate should have a minimum of a M.Sc. in Medical Physics or a related discipline. Experience in radiotherapy physics, certification by the Canadian College of Physicists in Medicine, experience with MRI and knowledge of the French language are desirable.

Candidates interested in applying for this position are encouraged to forward their resumes to:

Mr. Marco Carlone or Ms. Annie Doiron
Service de Physique Médicale
Centre Hospitalier des Vallées de l'Outaouais

Phone: (819) 561-8630 or (819) 561-8312
Fax: (819) 561-8314
e-mail : marco_carlone@ssss.gouv.qc.ca
annie_doiron@ssss.gouv.qc.ca

Position: Postdoctoral Associate/Fellow

Location: Princess Margaret Hospital, Dept. of Clinical Physics,
Toronto, Canada.

A position for a post doctoral fellow is now available at the Dept. of Clinical Physics, Princess Margaret Hospital in Toronto, Canada. The position is for one year and is within the stereotactic radiotherapy program directed towards the clinical implementation of Intensity Modulation Radiation Therapy (IMRT). The successful candidate will have a Ph.D. in Physics, Medical Physics, Biophysics or related field. Expertise with Unix programming would be an asset.

The Princess Margaret Hospital is a world renowned teaching hospital which treats over 6000 new cancer patients with radiotherapy each year. The Dept. of Clinical Physics consists of 14 physicists, 3 physics residents, 1 post doctoral fellow and other supporting staff. The stereotactic radiotherapy program consists of both the Xknife-4 (Jaws) and Xplan 2.01 planning systems from Radionics. The latter system uses the Mini-multileaf Collimator (MMLC). A dedicated Varian 2100 linear accelerator allows for treating upto 12 patients a day by the technique. A collaboration with the Hospital for Sick Children will allow for treating children as well by Spring 2000.

Please submit a curriculum vitae along with the names of three professional references to:

Dr Satish Jaywant.
Dept. of Clinical Physics,
Princess Margaret Hospital,
610 University Avenue,
Toronto, Ontario.
Canada M5G 2M9.

Fax: (416) 946 6566
E mail: Satish.Jaywant@rmp.uhn.on.ca

Faculty Position
Department of Physics & Astronomy
Laurentian University

The Department of Physics and Astronomy at Laurentian University invites applications for a three year limited-term position, subject to budgetary approval, at the Assistant Professor level. It is anticipated that the appointment would begin July 1, 2000. Applicants should hold a Ph.D. in physics with preference being given to candidates with at least two years of relevant postdoctoral or equivalent experience. The successful candidate would be expected to teach, in French and also in English, at the undergraduate level, and to pursue research in a field aligned with the department's research interests. These interests at present include neutrino astrophysics at the Sudbury Neutrino Observatory; medical or biomedical physics in collaboration with the North Eastern Ontario Regional Cancer Centre; laser trapping for MEMS applications; optical fiber sensors; and material characterization by acoustical methods.

Applications will be accepted until the position has been filled. Applicants should send a curriculum vitae, and should arrange to have three letters of reference sent to:

Dr. C.J. Virtue
Chair of Search Committee
Department of Physics and Astronomy
Laurentian University
Sudbury, Ontario P3E 2C6.
Fax: (705) 675-4868
e-mail: cjv@nu.phys.laurentian.ca

Laurentian University is committed to equity in employment and encourages applications from all qualified applicants, including women, aboriginal peoples, members of visible minorities and persons with disabilities. In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents.

Professeur
Département de physique et d'astronomie
Université Laurentienne

Le département de physique et d'astronomie de l'Université Laurentienne sollicite des candidatures pour un poste de durée limitée à trois ans, sous réserve de l'approbation budgétaire, au rang de professeur adjoint commençant le 1er juillet 2000. Exigence: détenir un doctorat en physique, avec de préference au moins deux ans d'expérience postdoctorale ou l'équivalent. La personne choisie enseignera en français et en anglais au niveau du première cycle et ses compétences en recherche devraient coïncider avec l'un des domaines d'expertise du département. Ces domines incluent à present l'astrophysique des neutrinos à l'Observatoire de neutrino de Sudbury; la physique médicale ou biomédicale en collaboration avec le Centre régional de cancérologie du nord-est de l'Ontario; le piège au laser pour les applications MEMS; les capteurs fibre-optiques, et la caractérisation des matériaux par les méthodes acoustiques.

Les candidatures seront acceptées jusqu'au moment où le poste sera comblé. Faire parvenir un curriculum vitae et les lettres de références de trois répondants à:

Monsieur C.J. Virtue
President du comité de sélection
Département de physique et d'astronomie
Université Laurentienne
Sudbury, Ontario P3E 2C6.
Télécopieur: (705) 675-4868
Courrier électronique: cjv@nu.phys.laurentian.ca

L'Université Laurentienne souscrit au principe de l'équité en matière d'emploi et encourage les candidatures provenant des femmes, des autochtones, des minorités visibles et des personnes handicapées. Conformément aux exigences canadiennes en matières d'immigration, la prioritè sera accordée aux citoyens canadiens et aux résidents permanents du Canada.

CancerCare MANITOBA

POSITION: **MEDICAL IMAGING PHYSICIST**
DEPARTMENT: **MEDICAL PHYSICS**
COMPETITION NO: **112-99-7153041**

LOCATION: Department of Medical Physics, CancerCare Manitoba, Winnipeg, Manitoba, Canada

POSITION OVERVIEW: The Department of Medical Physics, CancerCare Manitoba, seeks applications from experienced imaging physicists to provide leadership in the assessment and evaluation of mammography installations. This career position is part of a centralized Manitoba imaging physics program that provides consultations over the complete lifecycle of diagnostic equipment. Scope is included for varied clinical and imaging involvement, research and an expectation of teaching in the active graduate program. The successful candidate will work with a core team of imaging, radiotherapy, health physicists and other health care professionals. The imaging physics program is also associated with the provincial x-ray regulatory program. A full-services prototyping workshop and an electronics laboratory provide support. Continue professional development is encouraged, including completion and maintenance of certification. A university appointment will be available for an appropriately qualified applicant.

Qualified candidates should have a Ph.D. in Medical Physics or allied field with experience in clinical imaging. Direct experience in mammography imaging physics and CCPM membership would be assets. Leadership ability, strong interpersonal skills and well-developed communication skills are sought. Working hours are 37.5 hours per week. Apply in writing, including a curriculum vitae and the names and addresses of three references.

SALARY: Out-of-Scope

STARTING DATE: January 04, 2000

REPLIES: Interested and qualified applicants are invited to submit a detailed and current resume, together with a covering letter stating the Competition Number to:
CancerCare Manitoba – Human Resources
100 Olivia Street Winnipeg, Manitoba R3E OV9
Fax – 204-787-2979 Email – ardelle.jacques@cancercare.mb.ca

From the Editor:

by Peter Munro

This issue represents what I would like to see as the future for Interactions, a large number of well written articles that should interest a diverse audience. I am especially proud (oh-oh – here comes some hubris) of the two articles dealing with radiation accidents and radiation safety. This is because sources and contacts provided me with details never before published about the accident at Tokaimura as well as the AECB dealings with the University Health Network. In the language of past newspaper barons – "you read it here first!". I do have to admit, however, that I am somewhat embarrassed by the size of this issue – it may appear too large and intimidate people from opening its pages. I urge you not to succumb to this urge – although I realise everyone is so busy that yet another item to read may have low priority. The increased size is primarily due to the return of the theses abstracts after a one year absence. Kudos to Darcy Mason who's efforts gave me the dilemma of figuring out how to cram so many abstracts into a small space. The these abstracts indeed show how prolific Canadians are in the training of capable medical physicists!

Behind the scenes there have been some activities worth noting. One of my long term goals has been to create an archive of back issues of the Canadian Medical Physics Newsletter. After long hours scouring the offices here at the London Regional Cancer Centre, phone calls, and e-mails I managed to strike pay-dirt. It turns out that Sherry Connors has, unknown to many, been an unofficial archivist for the organisation. Sherry has agreed to provide copies of her back issues, which go back to 1983, to the COMP/CCPM Office. Copies will also be made and sent to the National Library – as part of the requirement for receiving an ISSN. It is not clear when the Newsletter started, so we do not know if we have all of the issues. So if anyone does have old issues of the Canadian Medical Physics Newsletter, please let me know!

One thing that struck me while reading some of the back issues of the Newsletter is how slowly some things change. In his last editorial, written in May 1986, John Scrimger discussed his desire to increase the content of the Newsletter that would be of interest to imaging physicists. Thirteen years later I am in a similar position. In future, I think that the role of imaging in delivery and monitoring of therapy will increase - the cover shows one exciting example of this trend. I believe that COMP is uniquely placed to improve the interactions (or should I say Interactions?) between imaging and therapy physicists.

We have a whole slate of changes that we would like to introduce to the web site. The first change is that we would like to introduce individual passwords. This is one of the key enabling features that should then allow us to introduce many other more sophisticated web-based services. Indeed, some of the changes are being forced on us. In future, abstracts from the annual meeting will be published in Medical Physics only if submitted in an electronic format.

There have been many changes in the Communications Committee in the past three months. Jacqueline Gallet has resigned from the committee and I am actively recruiting a replacement. More news on that effort in a future issue. However, the most important recruitment activity is to find a replacement for myself as editor of the newsletter. This has not gone very well with an under-whelming response to my advertisement in the last issue – no calls or e-mails. [The only response was from Paul Johns telling me that I would not get out of the position so easily. It turns out that because the annual meeting is so late in the year, I will be responsible for one more issue than I had planned.]

I really want to ensure the continuity of Interactions. To that end I have thought about a way of distributing the workload to more than one person. The task could be divided into corporate activities (New Products,

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