

The Shape of Things to Come:

Nobel Laureate

Dr. Lee Hartwell Speaks to the Kellogg Biotechnology Students

Interviewed by Robert Levak '02 and Sriram Jambaunathan '03, text Robert Levak

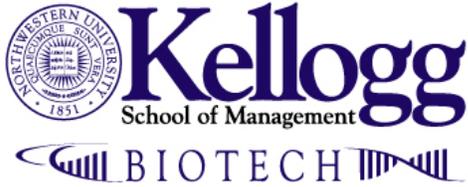
October 8, 2001 was a great day of recognition for a giant among giants, Dr. Lee Hartwell, president and director of the Fred Hutchinson Cancer Research Center and a professor of genetics at the University of Washington. He was announced as a recipient of the 2001 Nobel Prize in physiology and medicine. Collectively, Hartwell and two other British scientists, Dr. Paul Nurse and Dr. Timothy Hunt were honored for the work they contributed toward the understanding of how one cell divides into two daughter cells.

Hartwell began studying baker's yeast cells in the 1960's to gain insight into the fundamentals of cell division. Hartwell turned to yeast cells (*Saccharomyces cerevisiae*) because he believed it was best to understand a complex system using a simple model. Yeast turned out to be an excellent organism to work with because the cells rapidly divide and their division status is easily monitored microscopically as a yeast cell progresses through a series of morphological changes in the cell cycle. Nevertheless, at that time, researchers had no indication as to whether or not their discoveries in the yeast cells would be applicable to human cells. Hartwell states that he made "a fairly risky assumption" by deciding to use a yeast model to develop the frameworks for understanding cellular division.

As it turns out, Mother Nature worked out the basic differences in the cells of most organisms only once through the course of evolution. For instance, humans share about 50% of the genes that are in a banana and have twice as many genes as the fruit fly. Genetically, we are closely related to simpler organisms such as nematode worms and yeast replication. This biological unity amongst organisms turned out to be a fortuitous and poignant discovery of Hartwell's work since the cell division frameworks he delineated in yeast could then be applied to virtually all nucleated organisms including human cells.

Hartwell's efforts had enormous implications in the study of how human cells lose the ability to regulate their own division and transform into cancer cells. Simply stated, he developed a model for understanding the basics of carcinogenic.

Hartwell spent the majority of his career conducting research in the ivory halls of academia but he also co-founded Rosetta Inpharmatics in 1996 and has been the President and Director of the Fred Hutchinson Cancer Research Center – a non-profit organization – since 1997.



The biotech students flew to Seattle to hear Hartwell's opinions on topics dealing with intellectual property and escalating costs of new medical therapies. Hartwell also portrayed his vision of the future of medicine and his deep concerns in the realm of scientific medical research.

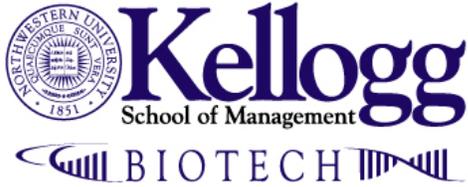
Interview:

Students: Medical science has advanced enormously in the last 30 years with the most recent breakthrough culminating with the Human Genome Project. Yet, diseases like cancer still have a significant impact on the lives of many, about 1 in 3 are diagnosed with the disease and 1 in 5 will die from it. Your research has greatly illuminated our understanding of the disease process in cancer. What do you believe are the next steps to eradicating such a disease or is this possible at all?

Hartwell: I think we're going to see an accelerated improvement for patients over the next couple of decades. As you say, there have been great advances but before we could have an impact on any disease, one had to understand it. We're now at a state where we do understand cancer and that's quite an accomplishment. There are about a half dozen mutations that activate a series of physiological processes in cells that convert them from normal cells to cancer. This has come about as a result of decades of work in very broad areas of biology, particularly in what we call model system: yeast, fruit flies, worms and mice. It's not one disease, it's enormously complex – there are 300 or so human tissues and probably more than 300 types of cancer. So, this series of 6 or so mutations that has to occur in each different tissue is among a whole constellation of 30,000 genes; thus, you're really looking for a needle in a haystack. The next revolution that was necessary and has occurred, is the genomics revolution – we now have the catalog of information for the human genome and because we have technologies that can access all of these genes in an experiment, we can look at their expression or structure in a cancer cell. We are now able to deal with the complexity. We have the fundamental understanding and the tools to deal with the complexity. I believe now, cancer is more like an engineering problem than it is a fundamental science problem. Researchers are applying these technologies and we've already seen a lot of advances and there will be many more to come in the future.

There is no question that biology is enormously complex and we have only scratched the surface. By saying that we understand cancer, what I mean is that we understand it at a level by which we can now do things that require information and things that will have a direct impact on cancer. It doesn't mean that we understand biology, which is so incredibly complex that we may never understand it fully.

Students: You and two other academic scientists co-founded Rosetta Inpharmatics in 1996. One of the goals of the company was to use yeast for drug discovery by combining



yeast genetics with DNA arrays. Rosetta eventually decided to slowly abandon yeast and focus more on mammalian cells. Can you elaborate on this?

Hartwell: Steve Friend and I began the drug discovery project because we feel that there is some fundamental problem with the drug discovery process in that it's not as rational as it could be and with respect to cancer, what you want to do is to develop therapeutics that will kill the cancer cell and that's not the way it's being done in pharmaceutical companies. What we did was to develop models of cancer in yeast. You can make a yeast cell that's defective in DNA damage checkpoints like P53 and then the question is, what would kill that cell that wouldn't kill a normal cell? With yeast genetics, it's possible to ask that question and to identify appropriate targets. It's a rational approach to target identification, which the pharmaceutical companies tend not to employ because they are primarily chemists and not geneticists. We then saw the value of incorporating transcript arrays because one of the problems with drugs is that you don't know what target they are hitting in the cell. If you can compare the expression patterns of a drug with a genetic knockout, which is a perfect model of what you would like the drug to do, you can tell what the drug is doing in vivo and compare if it's what you thought it would do. That was the second fundamental advance we saw in making drug discovery rational.

What happened over the course of time was that it did get supported into more of a mammalian approach because in the commercial sector there isn't always time to be rational and that's sort of unfortunate but it's true. My personal involvement in the company decreased rapidly but not my interest as it (Rosetta) took on other goals.

Students: Who was the other scientist involved?

Hartwell: Lee Hood was the other one.

Students: Where do you see the future of medicine heading? For instance, do you envision a time in the future when customized medicine, depending on an individual's genome, will be the norm?

Hartwell: In the short term, the biggest advances in cancer are going to come from earlier diagnosis, very sensitive and high resolution molecular technologies based upon the genetic changes in cancer cells, which will allow us to diagnose cancer earlier and more precisely. Most cancer can be cured if it can be diagnosed early and this is where I expect the big advances to come. The other area is coming out of the revolution that has occurred is in chemistry with combinatorial chemistry, so it's fairly easy now to make drugs against specific targets. As we understand the genetic perturbations in specific cancer cells, there will be more precise interventions like Gleevec for CML (chronic myelogenous leukemia.) The big advantage is not just therapy but prevention because



once you have a very specific molecule that doesn't have toxicity you can afford to give it to people that are at high risk before they have cancer. This allows the molecular therapeutics to move into the prevention arena and benefit the public health system to identify high-risk people. **These three things are marching in step – the molecular characterization leading to early diagnosis, the molecular characterization leading to precise therapeutics and the precise therapeutics leading to prevention.** It's a pretty exciting future in the short term.

As for individualized medicine, there's a lot of work that's going on now that's trying to correlate single base polymorphisms (SNP's) with disease susceptibility. This is an area where I think we haven't done our fundamental research. All of our understanding of biology is based upon inbred model systems where all the individuals are genetically homogenous and you see the effect of a particular perturbation. We know that we're on very shaky ground here because when you make the same genetic knockout in different inbred strains you get different results. We don't know what to make of that. It just doesn't fit into our paradigm, so our paradigm is wrong. It's not complete enough. The whole issue of understanding more about the variation and it's implications in an outbreed population is something that we lack fundamental insight. I think it's going to require another several decades of work in model systems to begin to understand that and it's an area that I'm personally interested in, and that we are working in with yeast.

I'm actually fairly pessimistic of analysis of SNP's having much impact in humans. The places that we will begin to learn about the complexity of variation in the human population is in the area of pharmacogenetics where the pathways are precisely understood and there is very rapid readout of metabolism throughout the organism. **We can begin to correlate polymorphisms and the important metabolic enzymes with response to drugs.** My bet is that it's going to be a lot more complicated than anybody thinks.

Students: So, Gleevec doesn't exactly fit the category of "personalized therapy" but is more of an example of a disease specific target based on a genetic mutation.

Hartwell: Yes, but I think that's where we'll discover the importance of human variation as we look at the drugs response rate amongst patients. We can start correlating this with the metabolism of the drug and then to make some sense of human variation.

Students: What about the costs of personalized therapies? There appears to be a fine line between keeping medicine affordable and continually investing in research and development. Society wants the cure and innovation, shareholders and investors want the profits and growth and yet, many individuals become disgruntled by the burden to pay for



these cures and therapies. Do you think it is possible to drive innovation and still keep medicine affordable?

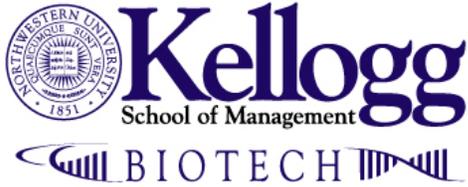
Hartwell: I don't approach this from an economics point of view, and I don't think one can. You can't do a market research analysis of where breakthroughs are going to come from and how much they are going to cost. I think patients want cures; they want advances in medical science. Sure they'd like them to be cheaper but given the alternative of expensive medicine or no medicine, they'll take the expensive medicine and that's going to drive the market. There's going to be continued research and there's going to be continued advances and some of it's going to be expensive. Ultimately, it becomes cheap once a medicine comes off a patent but you have to pay those initial costs. Another example is bone marrow transplantation – it's a very expensive technique but given the choice of leukemia or a chance to live, you pay the price. But, as a result of 20 years of research in this area, there is now a breakthrough in bone marrow transplantation that is making it an outpatient exercise. Instead of the 2 or 3 months of hospitalization that made the original procedure so expensive, within a couple of years, it's likely to become an outpatient procedure.

Students: Given time, treatment becomes inexpensive, but often, do we really have time? There is an issue of on the one side, giving the pharmaceutical companies time to recoup their R&D expenses but on the other side, we have millions of people dying of diseases like AIDS in Africa. When do you say enough is enough?

Hartwell: Yes, I think that then, we become humanitarians and it's encouraging to see that drug companies are making their therapeutics available to the third world at more or less cost and foundations like the Gate's Foundation is stepping in to help. Somebody has got to pay for it and I think the wealthier nations of the world ought to step up to bat. The US as a wealthy country puts very little in for foreign aid for food, for medicine, for anything and I think we ought to do a lot more, we ought to share our wealth for more important things rather than buying a new SUV every year. It becomes not a market issue but a humanitarian issue. An issue of leadership stepping up and inspiring people to want to give.

Students: There seems to be a delicate balance between rewarding innovative efforts and the need to keep other researchers interested in pursuing a niche, which is classified as intellectual property. This has also created an informational flow problem between researchers concerned about being "scooped" or giving away proprietary information. Do you believe that this has slowed down biomedical research?

Hartwell: Yes and no. I don't think it is slowing down much in the way of fundamental research because academics are motivated to discover things and tell everybody that they did it first. There's no incentive for academics to sequester it. I am a little concerned with



fundamental information that's accumulated in the "for profit" arena, as their incentive is to sequester it. It's less of a problem than I think it could be because there is also such a rapid need to generate profit that the research becomes very applied very fast and is not often, achieving fundamental insight. There is a sort of separation of function here where the academic sector focuses much more on fundamental insights and publishes its information.

Students: Most biotech companies are started and run by scientists and usually not businessmen. What challenges did you and the other three co-founders of Rosetta face in starting and running a company?

Hartwell: I really had very little to do with the running of the company and because of my position here at the Center, I wanted to be sure that my effectiveness here was not compromised by my colleagues being concerned about my interest in a private company. So, I did not serve on the board of directors but rather, I served on the scientific advisory board. I took no remuneration for that and I turned over my stock to the Center (FHRC). I separated myself rapidly from them and I tried only to provide scientific input when I could, but it was not very often. As for the issue that you bring up, managerial skills, even running a research group requires managerial skills—it requires sensitivity on how to get people doing what you want them to do, working together and cooperating. These are various types of skills that none of us as scientists receive any training in and that are a real oversight of the educational system. An oversight of the educational system that's even more fundamental than that is, we get no training at all in social skills. It's pretty important, as social skills are often what make people very successful in business. The real challenge is not learning how to do a balance sheet and other things like that, but rather it's things like: do people trust you, do they like you, do they believe in you, do you inspire people? Why don't we spend any time on those types of issues in the third grade!

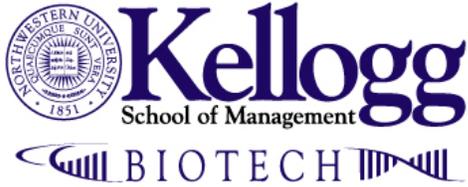
Students: It's all about people! People make the whole thing function and work.

Hartwell: Yes, exactly (laughs)

Students: Our organizational behavior professor would be really happy with you right now!

Hartwell: It just seems so ludicrous that this is something we ignore!

Students: What made you decide to make the transition from a young and exciting entrepreneurial company, Rosetta, which was recently acquired by Merck, to a nonprofit organization, the Fred Hutchinson Cancer Research Center (the Hutch, the Center)?



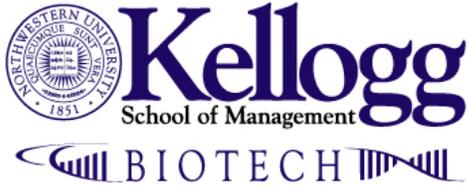
Hartwell: The story with the Hutch is an amusing one. What happened was, I was at a place in my scientific career where I realized that basic knowledge was accumulating to the point where it was really going to have an impact on medicine. I was interested in that and wanted to be more involved in the translation of knowledge to medical benefit. At the time when I was thinking in those terms, the director of the Center, Bob Day, invited me to become a division head here in Molecular Medicine, the Center has four divisions. I spent a little time considering that position and I spent some time here on a sabbatical. I turned down the position because I felt that the institution (the Hutch) was too divisional in its thinking and the issue that interested me was the connectivity of these disciplines rather than the individual divisions. Bob Day said, “So, what do you want to do?” I came in with a one page proposal that said, “I would like to be involved with trying to make the connections between the disciplines—I’ll have workshops, I’ll have retreats, I’ll get involved, I’ll work on this – I’ll spend half my time doing that and half my time doing my research.” So, he said, “OK” and called me a senior advisor and I did that for a year. I didn’t know that he was considering stepping down and that they were doing a search for his replacement and they came to me and asked me if I was interested in doing his job. Before they asked me, it had never occurred to me to lead an institution like this and at first my response was that I wasn’t interested. As I thought about it, I realized that they know who I am; they know what my interests are; they know what I’m trying to accomplish and this is a mandate: it’s put up or shut up! (laughs) So, I said “OK!” Obviously, this is the better position to try to accomplish those goals. It’s been a very exciting and very challenging learning experience to take on the leadership role of an institution.

Students: I imagine that there were more constraints in being involved with a for profit versus a nonprofit organization.

Hartwell: It wasn’t that so much. The fundamental question for me was: do you want to be involved in the science or do you want to be involved in the leadership? I thought about this for a long time prior to this opportunity coming up. I pretty much decided that one could make more of an impact in the leadership arena because the science was going to happen, it’s all there, there’s a huge momentum. It’s going to happen so, the question is how can one help bring it together and be of some influence.

Students: Does the leadership role in a nonprofit organization have more impact than in a commercial organization?

Hartwell: It depends really upon what your venue is. If it’s drug application; if you want to develop drugs or if you want to make a new diagnostic; if you want to contribute in a very focused application way, then you’re better off being in a for profit. If you want to



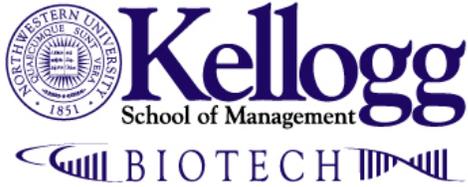
participate in the intellectual capital that is transforming medicine and society, then I think you want to be in a nonprofit arena.

Students: Do you feel you've achieved your goal of cross-divisional integration? By which metrics can you measure this? For example, by an increase in the number of research grants that the Center has received under your leadership.

Hartwell: I don't think you can measure it, and I think that you can never really know what your impact was. I think the institution (the Hutch) is becoming much more integrated but was on that course anyway. The divisions in the institution had been physically separated and they are now gathered on one campus and those are commitments that were made before I had anything to do with the institution. The science is driving the integration. Public Health Sciences, Clinical sciences, and Basic Sciences really operate with different vocabularies, different paradigms and completely separate training, so they tend to be fragmented but as the science becomes more molecular and more genetic and they are all dealing with common vocabulary and common elements, they are going to come together anyway. That's why I think they're more integrated in infectious diseases because all these areas talk about the infectious agent and they can relate to one another and as we relate over genes that will be happening on cancer. So, I think it's inevitable that there's integration and the question then is how do you help that along and create the most effective institution that you can. As for measuring success, I think the best way to measure it is with the people who are getting trained. It's the young people who will make the future. What I would like to see is that anyone who is trained here at the Center, regardless of which field they specialize in, gains an appreciation of what each of the fields has to add to solving the problem (cancer) and appreciates that and is capable of seeking collaborations in other fields. That's hard to measure too but that's how I think we will be a success.

Students: You mentioned earlier that in terms of looking for cures to cancer it is now becoming more of an engineering problem as opposed to a scientific issue. For example, Rosetta uses cutting edge engineering technology combined with computer technology to help us understand a disease state. Do you see this type of integration happening more and more with other science disciplines?

Hartwell: Yes, very much so! Biology is being transformed in a relatively short period of time to appreciate technology, information, and high throughput applications. We've just seen the value of DNA sequencing, we've just seen the value of transcript analysis, and technology too – whole body imaging. Data rich technology is essential to help us deal with the complexity of biology. You need a lot of parameters to help describe the space and to discriminate different things – it's like bar codes which are parameters that help to distinguish all the different items. Biology is so complex that technology is needed to help distinguish these data rich sources from one another.

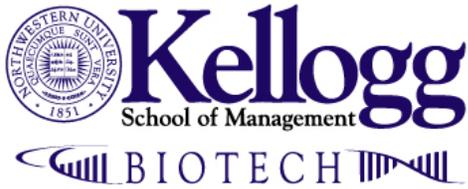


Students: What do you feel is the greatest challenge in making this integration happen successfully or what is slowing it down?

Hartwell: The biggest challenge right now is in clinical research or patient oriented research – it’s the people who interact with the patients. The reason is, and this is a very deep and serious issue in our culture, that there is a tremendous amount of anxiety in our country right now about patient’s rights, about patient confidentiality, about informed consent, and about how tissues are being used. There is enormously increased regulations going into place and a greater number of regulatory agencies and this is just crippling research! I believe that this is discouraging people from entering research in clinical medicine. People would much rather go into basic sciences where things are much simpler whereas if I see a patient, I’m at risk of getting sued! There’s “16,000” regulations that I have to pay attention too and if I overlook one, I could get sued! Who wants to go into that? Now, why is that happening? I think it’s happening because of the very rapid advances in science and the public is scared. They’re scared about cloning, stem cells, genetic information, gene therapy and genetic food, etc. **What’s going to happen, I’m afraid, is the most serious thing for the advancement of medical sciences is that the portal through which all information will have to be gained and all the sciences that are accumulating which has to go through that clinical trial step if we want it to be validated – the therapy, the diagnosis, the prevention – will continue to get constricted, constricted and constricted. Then we are going to decide that it wasn’t such a good idea and we need to open it up again! Do you know how long it takes to train somebody to do clinical research? From college, it’s about 12 years or so. You’re not just going to be able to open it up again, there’s not going to be the mentors.** Already the clinical researchers are the hardest people to find. When we offer a position for a clinical research position, we may get no qualified applicants and we have to get on the phone to try to find somebody who is qualified for this position. And, that’s before all of this heavy regulation as those are the people who were training when it was all glorious! The clinical research position is tremendously demanding because you have to learn two things, the science and the patient care to be a doctor. So, you have to be proficient in two professions, which require a tremendous amount of dedication, and then on top of it, it used to be glorious and it’s not glorious anymore. That’s what I’m worried about!

Students: You mentioned an interesting point about this fear in our society, is it also up to scientists and medical researchers to educate the public so that they have an understanding and not a fear of what is happening?

Hartwell: Oh yeah! That’s one of the most important responsibilities of scientists now and we haven’t spent enough of our time educating people. **This is one of the things that I enjoy about this job and after winning the Nobel Prize, I’m asked to give talks all**



the time and I like that, as it is a chance to educate and to let people know what is going on. Up until very recently, it's been a positive message – look at all the great things that are coming from medical sciences – and all of the sudden I've come to realize that it's in great danger at the level of training for the clinical researcher. So, I've got both this optimistic and pessimistic message. Now I don't think that the public's fear is unfounded! It is very relevant for us to decide what we want our lives to be like. It's very relevant for the public to decide whether they want embryonic stem cell research done or not and it's not up to the scientist. The scientists can tell the public, "listen there's a lot of potential benefit that could come from this but if you don't want us messing with embryos, that is your business." It's a cultural decision and not a scientific decision.

Students: Do you also think that it's potentially a legislative decision!

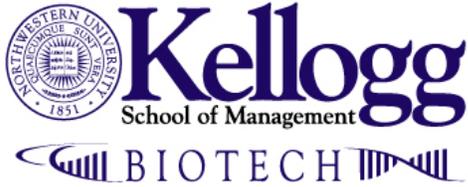
Hartwell: Well, that's how the culture speaks; it's all of this public pressure eventually developing into legislation. The down side of this is the hope that you can control by legislation, by putting 10,000 regulations in, you can assure that clinical trials will be safe. Clinical trials will not be safe, they're intrinsically a risky proposition and trust is always going to be required. We have to legislate around trust and risk. It's all about how much of that we want to accept.

Students: Do you believe that certain media sensationalism has propagated this fear? For instance, when a gene therapy experiment failed at the University of Pennsylvania and the 18-year-old boy being treated died, there was this massive public outcry and concern spurred on by the press.

Hartwell: I think journalists are rewarded for writing things that people want to read. If there is a lot of fear out there about these things then fanning those flames is going to be profitable for journalist in terms of selling papers. It is contributing to the problem but it's not the cause of the problem, it's symptomatic of the problem that we are afraid as a public with what is happening. It is sad that there's not more responsible journalism. For example, yes, there will be mistakes in clinical trials and people will die or be hurt. Very often these are people who have no other hope anyway and they know it and they're volunteering knowing that there is a risk. We are rather cavalier about the fact that 400,000 or so people die of lung cancer, which is completely controllable and yet we get very excited about one death!

Students: What do you see as the differences in the health care system within the US and abroad?

Hartwell: There are very great differences and one of the fundamental differences is whether there is universal healthcare or not. In countries where there is universal health



care they are much less concerned about privacy issues because they're not afraid that they are going to lose their medical insurance. For instance, in places like Scandinavia, medical care is much more uniform and less entrepreneurial and so, the patient records, the wait for researchers to get access to samples and that kind of thing lends itself to a much more freer system.

Students: As President and Director of the Fred Hutchinson Cancer Research Center since 1997, what is the biggest managerial obstacle that you faced thus far?

Hartwell: The Institution (the Hutch) director has several responsibilities and one is a day-to-day thing of maintaining quality control. Another thing is trying to foresee the future and making decisions that point the Institution in the direction of the future. The latter is the hardest because we are always guessing as to what the future is and so you have to bet on your guess because the decisions you make now will only play out in ten years. It's a long time span and it's the necessity of making the decisions that you have to trust to have a sense of where things are going.

Students: What do you feel are major contributions that you have made to the organization's development?

Hartwell: I don't really feel like I've made significant contributions. It's a terrific institution and has terrific leadership at all levels with very high quality. I am fortunate to be in this position because I am learning so much. The most important contribution I think I can make is to give my full attention to the job and not be distracted with my own individual research interests or national prominence or so many things that can easily drive you away from the job. It's a great institution, it's a great job and this is where I should be putting my attention!

Students: what do you have planned for the future? Are there any new passions that have excited you like the yeast model did 30 years ago (Nobel Prize winning work)?

Hartwell: As a scientific issue, what interests me is the robustness of biological systems; the fact that they can tolerate a lot of variation in their parts and still function. It's that capacity which allows all this genetic variation that we see in the population that is nevertheless compatible with relatively normal functioning individuals. I just think that's fascinating, and understanding more about how that robustness is now just in its inception and it will be about 20 years before we really have some insight into it.

Students: So, this is the area you are working on.



Hartwell: That's the area I am thinking about but I made the decision to do this job and that's what I'm doing. That area of science just gives me some place to connect with all various aspects of science that are going on and remain interested in because I have an interest myself. I'm trying to make sense of it all but I have a very small laboratory group and I don't spend much time there.

Students: So, there's a lot of curiosity that still drives you?

Hartwell: Definitely, I think you need to be puzzling about something yourself in order to stay connected and to want to pick up a journal and read it.

Students: It's been stated that thirty or so years ago when you decided to work with yeast models that you took a risk. Can you elaborate on this?

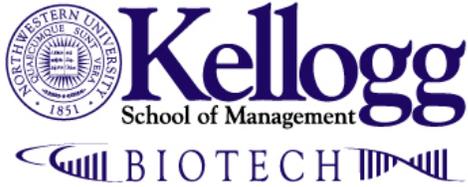
Hartwell: It was a risk because I was trained in one of the best laboratories for cancer research and the view of everyone in the field was that you study human cells to study cancer. That would have been the obvious career path to being a player. Those types of issues were not a concern for me. I didn't feel it was a risk but if it was a risk, it was from that point of view. As a result of my early education at Caltech, I've always been interested in the most fundamental questions and realized that I could only approach the most fundamental questions with a simpler system. And, there was certainly no guarantee that yeast would lead to anywhere that was relevant to human cells. The fact that it did was good luck.

Students: It was evolutionary conservatism that allowed for translation from the simpler model system of yeast to human cells!

Hartwell: Yes, we personally knew things should be evolutionarily conserved but you never know how much. The fact that you can take a DNA sequence out of a yeast cell and compare it to a human library and find the corresponding gene was unpredictable at that time. Nobody knew how much conservation there would be.

Students: Looking back over the last thirty years and going from basic research, to starting a for-profit organization (Rosetta Inpharmatics), to now heading a nonprofit research center (The Hutch) how do you feel your roles have changed in these three different arenas.

Hartwell: I think the biggest challenge in bringing the promise of medical revolution to people is in developing functional partnership between all the players and that we are not very good at this yet. Academic institutions like ours who have access to patients have to team up with for profit organizations that have access to technologies. We have to partner



here. The patients have to be willing to partner with us and trust us in doing the clinical trials. So there's a three way partnership there and that has to scale into a much larger thing because ultimately we have to start correlating all kinds of data across very large populations and so it's a collaboration among institutions to do this. Eventually, it all has to come back to the health care entities and the patients. There's this huge partnership we need to develop but right now it's very fragmented I think the important lessons for us to learn from the IT industry, which seems to move very quickly and seems to not impede too much progress by issues related to intellectual property ownership. Somehow they've learned to work around that. I don't understand it but that's where we need to go.

Students: Where do you see people trained as managers as opposed to scientists fitting into this partnership? Also, what is the role of managers trained at business schools like Kellogg where they are emphasizing the hard sciences in addition to the business skills?

Hartwell: That's a good point! I feel they will be key people because a good element in a partnership is that two people understand one another. You don't have to be competent in both areas but you have to understand one another. People who are purely of a business training and don't understand the science can't really make that partnership and the scientists who have been trained just in the laboratory have no business skills also can't make that partnership. I think these people who have enough understanding of two sides of the equation can build the bridges.

Students: What Kellogg is doing will really help this future. It's quite a unique program – the Center for Biotechnology at Northwestern University, which was an entity on its own, partnered with the business school at Northwestern, Kellogg. The business school now offers this exceptional biotechnology major in their program.

Hartwell: It's very innovative; it sounds like a great idea!