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## The Societal and Ethical Implications of Nanotechnology: A Christian Response

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Just about every magazine on the newsstands has featured nanotechnology in the past year or two. These articles usually speak of nanotech as the latest emerging platform technology that will substantially transform our material and social world, just as electricity and nuclear science did previously. It will create faster and smaller computers, allow us to combat all sorts of diseases, manufacture new stronger and lighter materials, and save our natural environment. The articles speak of the ways it will change how just about everything is designed and made and in the process change our entire world: not just the physical but the social and ethical aspects as well.

What is usually not mentioned in these articles is reference to the fact that nanotech could be the first platform technology to offer significant opportunities to include discussions of the social and environmental concerns in its development. Usually, it is not until a technology is well established that its social and ethical implications become known (Collingridge, 1980, pp.17-18). The National Science Foundation claims that with nanotechnology there is much "more opportunity to integrate the societal studies and dialogues from the very beginning and to include societal studies as a core part of the National Nanotechnology Initiative investment strategy" (Rocco and Sims, 2001, p. 2). The end result is that the development of nanotech may

not be left solely to the experts. The public may play a greater role than it previously has.

### Nanotech and SEIN

The government acknowledged the importance of this new platform technology in January 2000 when President Clinton (White House, 2000) established the National Nanotechnology Initiative (NNI), a federal program to coordinate funding of nanotech research and development. He justified the money by claiming nanotech promises to build materials ten times the strength of steel at a small fraction of its weight, to shrink all information in the Library of Congress into a device the size of a sugar cube, and to detect cancerous tumors when they are only a few cells in size.

Many go beyond this extensive vision to claim working on the atomic and molecular level will offer the opportunity to solve all of humanity's basic problems. In fact, one of the popular ways to present nanotech is to ask the audience to list the most pressing current and future global challenges that have potential technological fixes and then to claim nanotech will solve every one of them. Of course, no one mentions the potential social and ethical impacts of this new technology.

The government provided the opening for the greater community to become involved when

it passed *The 21st Century Nanotech Research and Development Act of 2003*. That act stipulates all federally funded research should include provisions for dealing with the social consequences of the work. The Societal and Ethical Implications of Nanotechnology section (SEIN) of that bill provides for 1) regular and ongoing discussions that involve the public, 2) involvement of social scientists and ethicists in setting the goals and priorities in federal research, and 3) assurances that efforts will be made to distribute the benefits of the technology to all Americans. The act provides an opportunity for community involvement from the very beginning and at many points of access along the line as this technology is developed.

Although this would seem a tremendous breakthrough in a democratic society, there has been very little discussion of it. Nobody seems too excited about soliciting the public's participation. Perhaps this reflects a belief that nobody really cares or perhaps it represents an effort to maintain things the way they are. If the public is not involved, those with power can keep control. Undoubtedly, others believe public participation would bring confusion, because the larger community does not have the special knowledge required.

It is true that the larger community does not share a common story and thus does not possess common values by which to evaluate technological issues. However, the public is composed of many constituent communities that possess more than a common zip code that can be used to group them for marketing purposes. These constituent communities share common stories and values. Their coming together in conversation is essential in addressing the common good of the larger community. This seems to be the objective of SEIN's provisions, and we believe this has to be the goal of any democratic society.

### **A Role for Religion?**

One of those constituent communities that have something to offer is religion. As part of the larger community, religion has historically provided ethical guidance and addressed social change. At the present time, it appears the larger community is willing to listen again to what it has to say.

In this article, we shall speak of the Christian Church as a representative of religion in general in order to simplify our argument.

Like society as a whole, religions do not share a single story. However, they do all draw on many similar assumptions. What we have to say about Christianity can be applied in some degree to other religious communities. We would urge that all religious communities have a right to have a role in the discussion.

To date the Christian Church has pretty much ignored the great influence of technology on society. She has addressed issues rather passively as they have been forced upon her, but has not regarded these important enough to involve much time by her leading theologians. Much of the work done has been in secular schools rather than church seminaries. This has meant that the Church has found it difficult to offer a united voice in technological times. At times, various church bodies have parted company and gone in completely opposite directions when forced to respond to technological advances.

A good example is the official response to the development of a safe contraception. When Goodyear and Hancock introduced the vulcanization of rubber in 1843, allowing good cheap, reliable condoms, the world finally had a good method of contraception with far-reaching consequences. The responses of the Lutheran and Roman Catholic churches moved in completely different directions. That separation has grown wider through each development up to and including the introduction of the pill in 1960. The Roman Catholics argued from the traditional natural law theory, insisting that the function of sexual intercourse is solely for the procreation of children. The Lutherans, on the other hand, took the current situation into consideration and modified the traditional doctrine. They introduced the expression of mutual love as a second function for intercourse. As a result, the Lutherans have accepted "artificial" contraception, while the Roman Catholics have rejected it as "unnatural" (Foltz, 1986).

Regardless of the official Church doctrinal response to this and other technological innovations, surveys for some time have shown the actual practice of laity in both bodies is virtually the same (Coffey, 1998, Hartman, 1998). Some see this as evidence of the demise of religious influence in a technological society, claiming as technology advances religion recedes. However, many others argue lay people are doing a better job wrestling with the demands of modern

technological society than their churches are. They argue that lay practice rather than official institutional statements represent the actual Christian position, and suggest the official bodies must begin listening to their laity as they address the demands of technology.

### **Naïve Views of Religion**

Some would argue that the Church has little to offer. As the Church has struggled to cope with rapid technological change, four naïve understandings, if not down right caricatures, of the relationship between Christianity and technology have developed.

The first of these caricatures sees modern technology as a God-given tool for accomplishing the goals of the Christian mission. It offers the tools needed to subdue and assume dominion over creation, an interpretation of God's instructions in the first chapters of Genesis. This model is sometimes read as allowing humans to use the resources of the earth any way they please, even if it seems to mean the destruction of the environment. God will act as a safety net, either intervening to correct our mistakes or even providing a new earth if necessary. Outsiders who impose this caricature on Christianity sometimes feel it is dangerous to have Christians working in areas of power, because they might find it easy to trigger the end times. This position would welcome all the innovations of nanotech, because they would offer the ultimate in controlling and subduing nature at even the atomic and molecular levels. It would have no trouble modifying animal and mineral but might balk when it comes to changing the human.

The second naïve view regards much modern technology as evil, because it enables humans to "play God." Technology enables humans to infringe on one of God's prerogatives, the right to create and destroy life. Only God should have the power to make decisions about the destruction of the world. Only God or the government in his stead should have the authority to take human life. Technology has changed all this. Nuclear power places the destruction of the world in human hands. Safe abortion has enabled individual women to make decisions about destroying human life. This position often places technology over against the "natural," taken to mean God's ways. Nanotech would then continue technology's ongoing transformation of the ways we define what is natural. In some

ways it would become the ultimate effort to "play God" as it would manipulate the basic "natural" building blocks of creation.

The third misconception sees all modern technology as neutral. It sees no moral difference between using tools, whether pencils or computers. It all depends on how humans use them. If we are able to develop a new technology, we are free and even obligated to do so. This model encourages the development of all possible technologies, because "someone is going to do it, and it had better be us." From this perspective, the community should leave the development of nanotech to the technologists. Those using this model do not appreciate Langdon Winner's (1986) claim that all technologies have political dimensions.

The fourth sees modern technology replacing traditional religion, offering fulfillment of the promises religion made and could not keep. Technology becomes God for modern people, satisfying their wants and needs. It creates a heaven on Earth. In some sense, technology has become nature. This position gives technology the freedom to do as it pleases. It welcomes all the power of nanotech to redo the creation and even to change the nature of the human.

### **A Mature View of Religion**

Although these four naïve models are still often used to characterize the Christian response to technology, they are essentially straw men. They would be hard to find in recent religious writing. They are not reasons to exclude the religious community from any discussion on technology.

A much more suitable model was offered by H. Richard Niebuhr in the middle of the last century. (Niebuhr, 1960, 1999) Niebuhr wrote with great clarity about the relationship between science and religion. He presented an "Ethics of Responsibility" in which he spoke of the Christian as a responsible self as she responds not only to the Church's scripture and tradition but also to the contemporary situation in which she finds herself. This responsible self operates in different communities with different centers of values. The health of the larger community depends on these constituent communities entering into dialogue, sometimes challenging and sometime complementing one another.

Two of those communities are the scientific and the religious. They operate ethically from

different centers of value. Niebuhr is not speaking of a strict separation of reason and faith or a division based on revelation and empirical discovery. Both communities use reason and faith, but from the different perspectives of their own centers of value. The difference involves the priority given each perspective. Niebuhr (1960) claims the science community's center of value is truth that gives priority to the search for knowledge. The Church's center of value is love, defined as caring for people and creation.

The two communities continually complement and challenge one another. Each in the best of times offers checks and balances to the other, providing a means for accountability. Devotion to truth alone may cause one to lose sight of the morally dubious uses to which scientific knowledge may be put in the social order. Devotion to love alone may cause one to forego the call to develop more efficient ways to implement that love. Therefore, it is essential that the communities continually converse and cooperate, if the common good of the larger community is to be realized.

Such a model confers benefits on science and religion as well as the larger community. First, the model enables both communities to work inside their own areas of competence. Christians have no special skills to evaluate how materials are developed or what dangers might be involved. However, their tradition employs the social values essential for healthy living and necessary for determining how technology is to be used. On the other hand, science has no competence in determining the social values that should determine how their knowledge should be employed for the sake of a better world. When scientists get into public policy, they are more ideological and self-interested than scientific. The model calls on both to refrain from pontificating from rigid doctrinal positions that they impose on the larger community. Instead it acknowledges nobody has all the answers and fosters conversation between communities.

Second, and most important, Niebuhr's model provides the means for social concerns to be applied to scientific and technological advances. Technology has difficulty with the overall effects of its work on society, because it focuses on expertise in isolated parts. To a certain extent, it has led us to a Tower of Babel scenario where in our efforts to make a name for

ourselves we have come to speak different languages and thus have divided our communities. One sees this general consequence, for instance, in the report on the first two years of the Gaithersburg (Maryland) Presbyterian Science, Technology, and Society Chapter of the Presbyterian Association on Science, Technology and the Christian Faith that observed their members were having difficulty relating to each other's work and beyond that to how their work related to the Christian message (Fritz, 2004). It involved speaking different vocabularies but went beyond that to the inability to see how their work fits in the larger context that gives meaning. That extreme division of intellectual labor in our modern world insures most consequences of our work fall beyond our individual domains of competence. We have all become experts but only in a very small area. Thus we all have become somewhat like workers on an assembly line who have lost contact with the purpose of what they are doing.

Niebuhr (2001) regards Christianity as one of the communities that attempts to make a better world by transforming culture. One way it does this is by seeking to understand the whole context of our actions. This means it is always speaking about the relationship of the parts.

### **Various Christian Views on Nanotech**

This certainly seems the model employed, even if unconsciously, by laity as they reconcile the claims of their faith and the technical society around them. It also seems to be that used by some of the more recent Christian writings about biotech and nanotech.<sup>1</sup>

These writings admit they seek a new maturity that learns from the past. They often state that they are ready to leave questions, such as "Where does life begin and end?" to the scientists. They counsel focusing instead on concerns such as "What is life?" and "Who has the right to make decisions about it?" which have always fallen in religion's area.

They also acknowledge that all parts of the larger community do not share their story or values and are now willing to cooperate on issues where they do. They call for conversations between the different communities that will lead to alliances, even though the parties do not agree on every particular, and they understand this will involve listening as well as talking.

So far, very little has been written about nanotech within religious circles. For the most part, what has been reflects the same concerns expressed previously about biotechnology. In some sense, they are intensified, because they seem to be carried to another level. Some humorously speak of moving from making life to faking life.

For the most part, these writers welcome the benefits offered by nanotech. They have no problems with developing stronger building materials. Most have few questions about modifying inert substances if this helps people. Surprisingly few question changing the basic characteristics of animals. But they do express three concerns that they believe are important for the human community to address at this point when dealing with a new platform technology like nanotech.

### *Human Dignity*

By far the first concern and primary issue is human dignity. Traditionally the Church has always proclaimed the sacredness of the individual person. Humanity is a given in the sense that it is defined by God not humans. Recent Christian writers (Ramsey, 1993, George, 2002, Colson, 2004) worry that a technological society makes the definition of the human a social construct. They warn that the only way to avoid making humans into means rather than ends is to emphasize the preservation of human dignity at every level and in all circumstances. The interests of the individual must never be sacrificed to the interests of science, technology, or society. So they call on the community to resist any attempt to make the human just another project or product of the technological advance.

These writers have spoken out against biotech proposals that use a person or create life for the benefit of others, such as using human embryos as research tools. They acknowledge nanotech could allow us to bypass this use of human life, but they are still anxious at the almost limitless technical manipulation and even manufacture of life available to this new technology. They are especially apprehensive when such modification would seem to be irreversible.

Most of these writers (Colson, 2004; Cameron, 2004; George, 2002; and Saunders, 2004) define the human as the “image of God.” This means it is characterized by its relationship to God as presented in biblical and traditional

descriptions. Each life is special as each person is one of God’s children.

Because the scriptures were written over hundreds of years, they sometimes disagree. These variances are resolved by making the Incarnation the ultimate archetype for the human. It is assumed the Incarnation is an endorsement of the human condition as lived out by this particular human, Jesus of Nazareth. When Christians confess him as the Christ of God, they declare him as the *logos* or rational principle structuring everything in relation to everything else. Jesus the Christ is the way to understand and bring all together.

An example of this can be seen in the writers’ response to nanotech’s promise to heal more efficiently. Writers, such as Cunningham (2004), use Jesus’ ministry as a norm for defining healing. Jesus’ healings allow the sick and lame to return to what the community regarded as “normal.” This involved the relief of suffering and the ability to participate fully in the everyday activities of the time.

They believe some of nanotech’s promises go beyond this kind of healing to the enhancement and basic reconstruction of the human. Some of the writers would like to accept some engineering at the atomic level if it brings relief to suffering. They fear, however, it could progressively redefine what is presently “normal” as defect.

The writers are concerned this blurring of the difference between traits and defects could eventually become the basis for a decision to eliminate those traits we judge inefficient or undesirable. We could decide which characteristics and qualities are worthy and which are not, rejecting the given as not acceptable in relation to the improved product. We would then end up challenging the worth of those who are burdensome, aged, handicapped, or not insurable. When discussing this issue some writers (Ramsey, 1993, Doerflinger, 2004) cite the Nuremberg Code, recalling science laid the foundation for the Nazis by contriving conceptual frameworks that excluded undesirable categories of human beings from our common humanity.

This danger is quite obvious in the work of futurists, such as Steve Kurzweil (1999) and Nick Bostrom (2003), when they claim technology is moving us to the next step of

human evolution, *the techno sapien*. They speak of the human as a scientific project, simply the latest step in technology's work to free humanity from the tyranny of nature and body. Nanotech becomes a merging of the human and machine that determines what is worthy to move on to the next level and what is not. *The techno sapien* that emerges in their writing represents a perversion of humanity from a Christian perspective by making individual comfort and happiness the narrow goal of the human project.

The writers (Cameron, 2004, Hook, 2003, Mitchell, 2003) insist the Church can never accept radical individualism's reduced goals that define human fulfillment as simply comfort and physical pleasure. In an imperfect and finite world the willful acceptance of some suffering in order to relieve others is a virtue. The suffering love of Jesus calls all believers to suffer voluntarily, if it will help another or the common good.

Some Christians (Manifesto, 2004) have expressed their position in "A Manifesto: The Sanctity of Life in Brave New World." The statement calls for a comprehensive ban on all human cloning as well as any irreversible, inheritable modification of the human. It also speaks against discrimination that would result from such modifications. The signers certainly do not represent the whole Church, but they do include evangelicals, Roman Catholics, and others regarded as conservative members of mainline denominations.

### **Social Justice**

That brings us to justice, the second concern. Although the Church appreciates justice as impartiality, she realizes in the present world that means special concern for the poor. Because of this, the scriptures have generally portrayed God as taking special care of the poor and needy.

Understanding this concern, many Christian writers respond to nanotech's promises with the call to make sure the weak and poor receive benefits from the new technology. They naturally would endorse SEIN's goal to distribute the benefits of nanotech to all parts of society.

This can be seen in the special effort of the Roman Catholic Church to promote solidarity as the primary standard for evaluating justice. The Vatican defines solidarity as a firm and perse-

vering determination to commit oneself to the common good. This principle plays the central role in its current debate about whether biotech and nanotech will provide means for feeding the world or enriching the few.

Nanotech might take a huge step in reducing poverty, if it enables us to skip a generation of infrastructure development like the cell phone did in Eastern Europe. The invention of small diagnostic machines that could be taken to poverty stricken Africa could bypass the need for the building of large hospitals. If nanotech simply develops cheap methods for attaining pure water and cures for conquering diseases, such as malaria and AIDS, it would greatly benefit the poor.

However, in the past technology has never fulfilled its promise to bring prosperity to all. More often than not it has brought instead great profit to the empowered and considered the plight of the poor as an afterthought. Most Christian writing about nanotech is concerned that the needs of the poor be considered from the very beginning.

The technology itself might create a new form of needy. Francis Collins avowed a Christian, who directs the Human Genome Project at NIH, warns we "must place as much emphasis on solving ethical, legal, and social issues of this rapid pace of genomic discovery as we do on hard science" (Mitchell, 2004 p.64). He speaks particularly of those people the diagnostic capabilities of nanotech might reveal to be highly susceptible to terminal disease. The premature introduction of predictive tests before the value of the information has been established actually could be quite harmful, if it leads to a new form of discrimination.

Justice should also involve taking the needs of future generations into consideration. Social responsibility would involve ensuring the long-range consequences for future generations are discussed. This would be especially relevant when it comes to modifications that might be irreversible. Christianity has something to contribute here as she has generally regarded her mission as extending far beyond a single generation.

### **Potential for Sin**

The third concern the Church brings to the table is an acknowledgement of sin in all human activities. The church recognizes every advance

in technology opens two universes, all the good and all the bad possibilities.

Almost everyone readily acknowledges there is a dark side to technical progress. It offers tremendous power for bringing a better world, but always by increasing as well humanity's capacity for destruction. Nanotech simply exacerbates this power, perhaps even irreversibly modifying parts of the biosystem. Often the response has simply been we have to be careful and trust the balance of power will keep things safe. This appears to be an assumption that people will do the good, if they know what it is.

Christianity sees the situation as far more complex. Sin is to do what we do not want to do and become what we do not want to be. It is to know what is good, but refuse to do it.

Therefore, Christian writers (Hook, 2004) call for regulations that go beyond special interest to control this sinful nature. Many of the writers regard government that represents the larger community as the best bet to hold back evil and protect the common good. They see recommendations such as the Foresight Institute's "Guidelines on Molecular Nanotechnology" as naïve when they speak of no need for government participation because of the natural beneficence of industry and the adequacy of self-regulation (p. 66). They also have trouble with leaving it all to peer review, seeing this as a conflict of interest as members of the same group decide who of their own is going to receive funding for the research.

Another regulatory concern has to do with the uncertainty of unexpected consequences in a new technology. Nanotech operates in the murky middle ground between quantum and classical mechanics. At this level materials often exhibit different behavior than on other levels. There is just no fully established explanation of the behavior we observe and no way to predict what will happen in the long run. This leads to questions about environmental destruction and health hazards. Nobody is sure what might happen if we ingest, inhale, inject, or merely bring nanoparticles into contact with our skin. People worry about accumulation in our lungs and even passage through the blood-brain barrier.

We were surprised we did not see more concern in the writings for the safety of workers presently handling nanoparticles. In our personal

contacts, we did receive reports of management constantly debating the safety of working with nanoparticles, and we also heard tales of workers being assured there was no danger involved at all. We are uncertain if the safety talks are confined to management's anxiety about liability after its experience with asbestos and painkillers. Regardless, most people are uncertain what can be done. Wearing masks and gloves would seem to be futile.

Again the Church has no expertise in determining the technological answers to such questions, but she can call for confronting the problem honestly and openly. As she tries to balance the needs of the individual and society, she naturally supports those who counsel accepting a precautionary principle that could be used to postpone development until more is understood about the safety issues involved.

### **Our Concerns**

All three of these issues found in recent Christian writings are ones the larger community would do well to confront in the near future. We believe Christianity also points to three more concerns, shared by many critics of technologies that are worth examining as we consider the development of nanotech.

### ***Technology Should Be a Means and not the Ends***

Christianity regards technology as a tool the community uses to solve basic human problems, such as feeding, clothing, and housing all people. Ever since 1967 when Lynn White articulated how Christian theology had contributed to the exploitation of the earth, it is hard to find any Christian writers who define God's will as subduing nature. Instead they point to the many passages of the scriptures that understand the Genesis commission in terms of humans caring for creation as God's stewards or managers. Humans are caretakers who treat creation as God's representative rather than masters who force nature into their own goals. Care, not exploitation, is the norm.

In such a scheme every effort should be made to ensure technical means do not become the driving force that shapes social ends. Perhaps by default technological development in the past has followed the dictum of the 1933 Chicago World's Fair that stated "Science finds – Industry applies – Man conforms." Such an approach guaranteed an "end of pipe" ethics that

reacted rather than guided. SEIN like the Church is attempting to change this, making the common good of the larger community the determining factor.

In fact, often technology has tended to divert the community from confronting and solving its basic problems. There is danger that nanotech will exacerbate this danger as it operates on the atomic and molecular levels moving us further from real life community. With more specialization and distance from the real world of community, it is much harder even to relate what is going on to the realm of sense. It makes it easier to ignore rather than solve basic human problems.

Care must be taken to make sure technology as well as any other available tool does not operate for its own sake alone. Leo Marx (1987) warned that technology should be the means for achieving a better society. When technology becomes the end for its own sake, technological progress focuses on the new and improved. In this case, improved may not better society at all, but simply be technological. We must make sure that the goal is a better world and not simply better technology. In this case, technology would become an idol from a Christian perspective, because it would replace God and his will.

### *Speak for the Voiceless in Creation*

We think Christianity also calls the community to go beyond preserving human dignity to considering what tampering with the basic structure that supports all life might mean. Humanity's role as God's manager extends beyond speaking for the common good of the human community. It also calls us to speak for the rest of creation that does not have a voice.

We can no longer simply regard the creation as an environment for humanity. We have come to understand more and more how all of creation is interrelated. Caring for the earth, plants, animals and the biosphere is crucial. One must ask if we acknowledge the organic system of the universe sustains all people and things, we are not then forced to ask also if there is much difference between moving atoms and molecules in inert materials, plants, animals, and human beings. This is especially critical when we have to acknowledge we do not understand the consequences of what we are doing and how these will affect the system.

John Rawls (1971) argues that society is created through a social contract between all members. This contract ensures that all people's interests should be properly protected. The problem of justice arises because individuals make competing claims to the same goods produced through social cooperation. If nanotechnology is socially produced, then all must share in the many benefits its supporters claim will follow. There needs to be voices that protect the voiceless from losing out from these benefits.

### *Body and Community*

One way to make sure this technology does not divert us from taking responsibility to care for life and the environment is to emphasize the need to gather in embodied community to address the situation. It seems natural for the Church to endorse SEIN's call for citizen panels that include all parts of larger community: university, industry, government, and the public. Christianity has always recognized the necessity of the body for personal identity and social relationships. Embodied community is where the social confrontation and commitment demanded by ethical action takes place (Foltz and Foltz, 2003).

Certainly getting the public involved will demand using mass media wisely. That kind of exposure and education has become essential in modern society. But even more important is bringing people together in local settings to discuss the issues technology, and especially now nanotechnology, raise.

The Church can help by hosting citizen panels. She offered her buildings as safe gathering places in the Communist Eastern Block when diverse groups coordinated action for bringing down the Berlin Wall. She can do the same again as groups gather to share ideas for using technology for making a better world.

The Wilberforce Forum headed by Chuck Colson has been bringing people together face-to-face from all sides of the discussion. Their gatherings have included Roman Catholics, Mainline Christians, evangelicals, secularists, scientists, and even futurists as Nick Bostrum who speaks of the post human. Although the group is generally regarded as a rather conservative Christian voice, its aim is to bring together people from many different positions to discuss common problems.

### Need for Change

The six Christian concerns listed above would all seem to be useful issues to address as the society confronts the development of nanotechnology. It should be obvious that the inclusion of religious communities, as well as the many other social groups, in the discussion concerning this platform technology would greatly benefit society at large. Just about everyone agrees nanotech not only holds great promise but also makes great demands on our society.

The National Science Foundation speaks of the changes that will have to be made in education and organization if nanotech is to make good on its promises.

Development of nanotechnology will depend upon multidisciplinary teams of highly trained people with backgrounds in biology, medicine, applied and computational mathematics, physics, chemistry, and in electrical, chemical, and mechanical engineering. Team leaders and innovators will probably need expertise in multiple subsets of these disciplines, and all members of the team will need a general appreciation of the other members' fields. Developing a broadly trained and educated workforce presents a severe challenge to our four-year degree and two-year degree educational institutions, which favor compartmentalized learning. Because current educational trends favor specialization, there must be fundamental changes in our educational systems. However, introducing new degree programs in nanotechnology that provide a shallow overview of many disciplines, none in sufficient depth to make major contributions, may not give students the training that is needed to meet the future challenges. The right balance between specialization and interdisciplinary training needs to be worked out through innovative demonstration programs and research on the education process and workforce needs.

Education in nanoscience and nanotechnology requires special laboratory facilities that can be quite expensive. Given the cost of creating and sustaining such facilities, their incorporation into nanotechnology workforce development presents a considerable challenge. Under the present education system, many engineering schools, let alone the two-year-degree col-

leges, cannot offer students any exposure to the practice of nanofabrication. Innovative solutions will have to be found, such as new partnerships with industry and the establishment of nanofabrication facilities that are shared by consortia of colleges, universities, and engineering schools. Web-based, remote access to those facilities may provide a powerful new approach not available previously. (Rocco and Sims, p. 13).

Many of the changes called for in this 2001 report on a National Science Foundation conference have already commenced. Universities have established new avenues for interdisciplinary work and have entered into new and extensive alliances with industry and other universities. These, however, are simply the changes necessary in technological education and organization. Christians see great demands on social and ethical areas as well. In the middle of the last century Niebuhr (1960) worried that in our obsession with technical education we might be educating future leaders with the virtues of technology and rational knowledge but leaving to chance the personal development of the moral habits of integrity, justice, courage, and self-control necessary for using these responsibly in communities.

The social and ethical implications of nanotechnology are too important to leave to chance or to just a handful of people. In the past efforts were made to keep politicians and the public out and to leave the decisions to those who understood science and technology. These typically were the people engaged in the project itself. With the great power released by modern technology the public can no longer be left out. There is a lot of hoopla about the promise of nanotech to change our world. Christianity welcomes this potential and speaks out to make sure this change serves the real needs of the larger community and not simply benefits a small elite. It recognizes that basic problems will not be solved by the simple development of new technologies but rather in the relationships between people that make sure that technologies serve the common good.

A responsible handling of these critical questions demands the contributions of social scientists and philosophers as well as people from business, the laboratories, environmental organizations, churches, and other groups in the discussion. It is time to reject the idea that there are only a few designated stakeholders that are

qualified to evaluate possibilities, manage the risks, and guide technology toward beneficial outcomes.

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### Notes

<sup>1</sup> (McQuade, 1998; McQuade, 2001; McQuade, 2005)

<sup>2</sup> A good example of these positions can be found in two recent anthologies: Colson, C., and Cameron, N. (2004), (Eds.). *Human Dignity In the Biotech Century: A Christian Vision for Public Policy* and Kilner, J., Hook, C., Uustal, D. (Eds.). (2002). *Cutting Edge Bioethics: A Christian Exploration of Technologies and Trends*.