COMMENCEMENT TALK AT GRADUATION CEREMONY: DEPARTMENTS OF PALEONTOLOGY AND GEOLOGY AND GEOPHYSICS, UNIVERSITY OF CALIFORNIA, BERKELEY

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by Clyde Wahrhaftig

A commencement speaker is usually an old windbag exhorting the graduates to mighty goals in the glorious world that awaits them. I will maintain that tradition, although the world out there is not nearly as pleasant now as when I graduated in '41, and the goals I shall recommend are not particularly glorious.

My talk is in three parts. The first part is an abridgement of a talk I gave at a Penrose conference about 6 years ago. It asks whether economic growth, the device that currently solves our social problems, can be sustained indefinitely. The second part investigates why we seem to need to grow. And the third part explores alternative lives and goals, if growth should prove unsustainable.

You may wonder why I talk about economics at an Earth Sciences ceremony. Well, there are three reasons: First, Ian promised me I could say anything that was on my mind, and this has been on my mind lately. Second, a forum of earth scientists seems an appropriate place to discuss something that involves the finiteness of the earth, as well as the finiteness--one might almost say the infinitesimal character--of our duration on it. Third, the University and its departments are not immune to the problems I shall describe. In fact, their activities are central to them. And the solution to these problems will probably have to take place in your lifetimes.

Since I am going to talk about the future, and not the immediate future ---although it may be more immediate than you think--- I will start by answering a question the thoughtless ask whenever the future is brought up:

"What has the future ever done for me?"

The answer is: "It has put purpose into your life".

Each of you can prove that answer by asking yourself what you would be doing if you knew for an absolute certainty that the moment you died, your wife and children and all of humanity would die with you, and no one, anywhere, would be around to appreciate what you had done. I am sure that if you had such certain knowledge, most of you would not have been knocking yourselves out to earn the degrees you are about to be granted, nor would my

colleagues and I have been wasting our time teaching you. We would all be finding other, surer ways of enjoying ourselves. The fact is that we---at least those of us in a university---spend most of our time working for posterity.

Now we are all of good will and want our impact on posterity to be beneficial. We want the future to think well of us. The first question I explore is whether many of our actions and the values that lie behind them are counterproductive of this end.

I

We are currently in an economic depression, whose chief cause, we are told, is that our economy is not growing fast enough. Last week I heard on the radio that Japan has finally joined the community of economically depressed nations because the growth of the Japanese GNP has fallen to only 3 percent a year. As I understand the economists' plea, we must have at least 4 percent a year or preferably 7 percent a year growth in GNP if we are to have a healthy economy and full employment. Furthermore, we justify the inequities in our society on the grounds that only by allowing the enterprising and inventive the reward of their efforts, can the least well-off in our society be afforded the <u>increasing</u> affluence that this economic growth would provide.

Now there are many ways in which we grow. There is population growth, which I am not going to discuss, because I think everyone here, and most intelligent people agree is not sustainable---in fact, our world population probably already exceeds the capacity of a world with its normal supply of droughts and crop failures to support indefinitely. Even most of the world's religious and secular leaders are agreed that we must stabilize our population. They just find all the practical means of attainment so morally repugnant that they want to ban them. However, we are going to have population control, make no doubt about that. The question the Pope and others have to decide is whether it is more humane as birth control or as death control---that is, by famine, disease, and war. So in the ensuing discussion I will assume a stable population.

The growth the economists are thinking about is growth in what they call Gross National Product (GNP)----remember, the GNP includes both candy and trips to the dentist to repair your teeth. The GNP is made up of goods and services, and I shall talk about both.

First, goods: Goods are material things, either manufactured articles or agricultural products. The manufactured articles require raw materials, fabricating plants, and energy to obtain and transport the raw materials, to manufacture articles from them, to distribute the articles---and in some cases, to use the articles. The agricultural products also consume energy in farming, processing, and delivery. In America we use 7 to 12 times as much fossil energy as we do chlorophyll-fixed solar energy in producing and distributing our food. Hence a major component of growth in goods is growth in the energy needed to produce them. At the moment we are learning how to conserve the amount of energy used per item of production, but conservation of this sort can go only so far, and ultimately if a high rate of growth in the annual production of goods is to be maintained, our rate of growth of energy consumption must again resume its old values.

How long can energy growth be sustained? These equations contain my answer:

$$(1.07)^{10} = 2$$
$$(1.03)^{23} = \not 2\, 3$$
$$2^{20} = 10^{6}$$
$$E = kT^{4}$$

The first two equations say that a 7 percent growth rate has a doubling time of 10 years; and a three-percent growth rate a doubling time of 23 years. The third says that 20 doublings is a million-fold; so that in 200 years anything growing at 7 percent a year would be a million times larger than now, or in 460 years if it grew at 3 percent a year (i.e., depression rates).

Now is energy growth at these rates sustainable? I will not go into arguable questions of pollution, CO_2 buildup, impact on food supply, or whether we could find that much energy, although I believe that one or more of these constraints will catch up with us before the limit I will discuss. I assume that benign fusion power suddenly comes on line, and that it is inexhaustible. Assuming that, I wish to concentrate on the ultimate limit, imposed by the Stefan-Boltzmann Law, a law of physics

that I understand we can neither amend nor violate, which is given by the last equation. This states that the flux at which a body such as the earth radiates energy is proportional to the 4th power of its absolute temperature. The constant k in this equation is one of the fundamental constants of nature.

Now practically all the energy we use in manufacturing, transportation, etc., turns into heat, and must ultimately be dissipated into outer space as radiation. The earth receives from the sun each day about 36×10^{20} calories of solar radiation, and must re-radiate on the average that exact amount, if the atmosphere and oceans are not to heat up. In 1975 we used for manufacturing, transportation, and the like, about 1/18,000 of the energy per day we receive from the sun, so our current impact on the earth's energy balance is negligible. However, at a growth rate of 7 percent, in 140 years we would be producing as much energy as we receive from the sun, and in order to dissipate this double burden of heat, the temperature at the base of the stratosphere would have to be 50°C (90°F) higher than it is now. Because of the greenhouse effect of the additional water and CO_2 this would put into the atmosphere, the temperature increase at the earth's surface would be much greater.

Obviously, long before this happened, either the earth would become uninhabitable or our economy would have broken down completely---or else have become a no-energy-growth economy.

Can we grow in rate of consumption of material goods without growth in energy? I think not, because raw materials from which these goods are made, especially if they are mineral raw materials, require more energy per unit to extract as we run out of the rich and accessible deposits and have to mine the leaner and less accessible.

Well, say the economists, if we can't grow in goods, we will simply grow in services. So what is a service? It is basically a human interaction in which an exchange of money is involved. For example, we, the faculty, teach. For this we receive salaries form the University, paid mainly from taxes that you, your parents, and other taxpayers have contributed to the State. More direct money exchange occurs when you get a haircut, see a doctor or lawyer,

and interact in other ways that I could enumerate but won't, and these are all economic services, part of the GNP.

Now probably the most distressing difference between life today and our lives only 20 or 30 years ago is the loss of spare time. We are expected always to do more than we seem to have time for, to interact with more people in more different ways than we used to, to read more articles in more journals. The reason for this, I think, is that our economy has been growing in services, and we are finally beginning to reach the saturation point. A service performed by one person to or on another takes both parties' time, and we are running out of time. So we can't grow in services either. Hence the growth the economists demand is not sustainable, and must cease, the sooner the better.

II

Why do we seem to have to grow?

Growth is needed, we are told, in order to achieve full employment, and so that all that is manufactured can be sold. Because innovation constantly introduces labor-saving devices, and because many goods, such as buildings, bridges, and houses, don't wear out, the only way to keep everyone gainfully employed is to continue to grow economically.

It seems to me that, if we are producing everything we really need (and I think that we are doing that, and producing a lot of things we don't need and would be much better off without) and some are unemployed, someone else is working too hard. So a simple solution, in principle, for unemployment, would be to cut the hours of work per week, reduce take-home pay proportionately, and make up the needed work by hiring the unemployed.

Our society seems to have no mechanism for doing this simple thing. The reason we don't, I think, is that the people who control the labor-saving machinery benefit most by reducing the number of their employees and pocketing the money saved, not by reducing the work week. The only trouble with this, of course, is that machines don't buy consumer goods.

Another reason for growth is that the livelihoods of many people depend on it. Growth of cities, and of city centers like downtown San Francisco, is needed to keep carpenters and welders and stone-masons busy, and also to employ architects, engineers, and engineering geologists, all graduates of

this University. Many professionals beside the three I've just enumerated depend on growth for their raison d'etre. In fact, I think I've identified the industry in this country with the greatest built-in requirement for growth. It is the production of Ph.D.'s.

As I understand the rules, each of us faculty members is supposed to have at least two Ph.D. candidates studying under us at all times, and we are supposed to drive them out of the nest at the end of four years, armed with a Ph.D. and burning with a desire to do as we have done. Now if all wishes were granted---the Administration's, that we had our students; the professors', that they finished their theses on time---or at all; and the candidates', that a suitable berth awaited them at another prestigious university, there would be doubling time in Ph.D.'s of approximately 2 years. At that rate the entire population of the U.S. would have a Ph.D. in about 40 years---and would be looking for a place to exercise the perques the Ph.D. is supposed to confer. Fortunately, most of these wishes are not granted---many are not even desired. Although I have almost fulfilled my quota, only two of my Ph.D. students are currently teaching at Ph.D. granting institutions. Most of the others work for the USGS or teach at schools that do not grant Ph.D.'s.

But I think that there is a third reason for growth---one that involves our personal motivations, especially at the University. This is our desire to leave some recognizable mark on the future---a mark that will somehow be identified with us personally. This desire became paramount among creative people only since the beginning of the Renaissance. Before that, most creative people---the cathedral builders, for example, were content to live and die anonymously.

This is a motivation from which much good flows, but from which much harm can flow also. Great writers write books because of it, and composers great music. Mozart, for example, was obsessed with the desire to be known as the greatest composer the world had seen.

I think this desire stems from a wish for immortality, and a fear of the annihilation of self that comes with death, now that most of us can no longer accept the myth of spiritual immortality. In the sciences, this has become a scramble to make and publish discoveries, and to show, if possible, that what you have discovered has wide implications. At times it is an undignified race for priority---as documented in The Double Helix. Now

although the contribution of an artist such as Mozart, I am convinced, is unique, it is doubtful that any scientific discovery would not have been made within a decade or two of its occurence if the discoverer had not lived. The evidence is the large number of fundamental discoveries ---such as the Calculus and Evolution---that were made almost simultaneously by two independent researchers.

Furthermore, what was originally simply a desire, somwehat akin to vanity, for scientific eminence by those hired to teach at universities, has become institutionalized by those same universities as one of the conditions of employment, so where scientists once made discoveries out of eagerness and curiosity, they must now make and publish them whether they are eager and curious or not. As a result, one of the fastest growing industries around is scientific journal publication. When I got out of college there were three or four journals that kept you abreast of nearly everything that was going on in geology in North America. Now there seem to be 30 or 40 one should read. (Part of the goods-and-services problem----A journal article is a service its author has provided for me as well as for his ego---but one I may not have time to take advantage of).

III

These are the inducements to growth. What must be done to avoid them?

As I mentioned, inequitable distribution of the benefits of our society can only be justified, in the eyes of most moralists, by appeal to the benefits the enterprisingly wealthy are going to bring to their poorer fellows. One social theorist, Fred Hirsch, in The Social Limits to Growth, has shown quite convincingly that even this argument breaks down, for as our material needs and wants are satisfied, what we seek---and are dissatisfied if we cannot get---are positional goods, goods that depend on our position relative to others: servants; a home with a view; a vacation in a secluded spot; a job without deadening routine, or a position of authority---such as the authority a professor exercises over his students. Such goods require others who do not possess them, and hence affluence only increases the proportion of the dissatisfied.

Now we here today are very well off, especially when it comes to positional goods. We have hit upon ways of earning a living that are so intrinsically enjoyable that we wouldn't trade them for any other. As one

young man I know put it, we are being paid to do our hobbies. Much of this work isn't absolutely essential, and we are supported in it by a structure that involves the government's police and taxing powers, and by the autonomy granted businesses in the disbursement of their moneys. If the legitimacy of our positions should be questioned, we should be able to make clear how paying us to do what we do enriches the lives of others---and in a no-growth society. Some, of course, will be trying to find more gasoline and copper for their cars, or being sure buildings don't slide downhill. But that won't take all of us in a no-growth society, as the recent alarming increase in unemployment amoung geologists shows. And we cannot simply say that we are adding to the store of human knowledge, if most of those who question our legitimacy cannot share in that knowledge.

If we look around to see how the positional good of employment is currently distributed, we find society divided into three parts: There are those with enormous amounts of leisure, but lacking either the material or intellectual resources to use it in a satisfying way. These are the unemployed. Then there are those who work hard, but at jobs they don't enjoy. They have little leisure, and although they have material resources to enjoy that leisure, they commonly lack the intellectual resources to enjoy it in a way that isn't excessively consumptive of natural resources. Finally, there are the few who have jobs they enjoy, but also lack leisure. Moving abruptly to a no-growth society would greatly increase the members of the first group, in part through recruits from the third group, and would create a dangerously explosive situation, even if everyone's material needs were met. Clearly an equable no-growth society would have to do what I suggested earlier, reduce the work-week and give everyone much more leisure; and a truly equable society would give those with the least desirable jobs the shortest working hours, and hence the most leisure. Hence, in a no-growth society everyone will have more spare time. Now people get bored with nothing to do in their spare time, and bored people can be dangerous, or at least expensive, especially if they try to dissipate their boredom with thrills. Hence something more must be done, if our no-growth society is not to become brutal and repressive.

This brings me to the one form of growth that will never cease, and in which we should all be involved. That is the growth, and particularly the

intellectual growth of the succeeding generations, ---as well as the continued intellectual growth of ourselves and our own generation. In a society as totally interdependent and technological as ours, it is dangerous for all of us that a large fraction of our citizenry, probably the great majority, don't have a clear idea of how either the natural world or the social world operates. Because of this ignorance, dangerous policies get adopted on a state or national scale.

One of the virtues of being human is the capacity to appreciate and enjoy the world around us in a variety of ways not open to other species. This world, both natural and human, is excessively rich in things to enjoy. There is a vast number of really good books none of us will ever have time to read, music to play and listen to, history and philosophy to read and ponder, and nature to be understood and enjoyed. The satisfaction that comes from this appreciation needs no great income, and makes relatively few demands on the earth's resources. But it takes training--lots of it--to develop this capacity for enjoyment, and this is why those of us here are among the favored. We have been forced to aquire that training.

In a well-ordered no-growth society, education would probably be the largest industry and would employ most of the adults. And education should be a much larger industry in our own society. But it would not be an industry to train an elite for those rare positional goods. Fred Hirsch has shown that that won't work. Instead it should train all the citizens to their maximum capacity to understand and enjoy the world around them. Now this kind of education, being a public necessity, cannot be a commodity handled in the market place. It has to be one of those goods available to all regardless of income. It has to be public education paid out of taxes. But it has to be good education.

Hence we need a far greater effort, at the grade school and high school level, to get the intellectual product of science across to all future citizens, not just those who happen to be easy to teach. We have to make learning enjoyable for the rest. So, in the well-ordered society, I see far more of our best graduates going into high-school and grade-school teaching, at least for part of their careers. In such a society, and even in our imperfect society, a high-school teacher who inspires in students a

a love of knowledge for its own sake would be far more valuable than the most prestigious university scientist.

Well, that still seems like a lot of time. What else do we do?

I think that we follow the advice of the Declaration of Independence, and pursue happiness. So what is happiness?

Dictionaries don't help much. I had to do a little research, but it isn't statistically very sound, since I had only one subject for my investigation---only one person with whom I was intimate enough to ask such personal questions---that was me. Nevertheless I will share my discoveries with you. My investigation was conducted by finding out what made me unhappy.

I find that happiness has four ingredients.

The first ingredient is a sense of well-being. I am unhappy when I have a toothache or a hangover.

The second ingredient is satisfaction with one's lot. That is, satisfaction with one's physical surroundings and with one's situation in life relative to others; also satisfaction with the jobs one has been assigned or adopts. Satisfactory physical surroundings don't necessarily mean comfortable physical surroundings, for I have been happiest when my physical condition resembled those of abject poverty: -sleeping on the ground or beneath a thin canvas shelter, exposed to the worst weather, lacking even a beast of burden and having to carry everything I needed on my back. But the work was exciting, I had companionship, and the surroundings were magnificent: the Alaska Range or the Sierra Nevada.

The third, and a most important ingredient, is satisfaction with oneself. I find that I am most unhappy when I have committed some goof-up, caused someone harm, or failed to do something I should have done.

How well is society set up to promote this aspect of the pursuit of happiness? Not very well, for we all rise in life through the years, promoted up the ladder of positional goods, until we reach the level of our incompetance.

Then we stop rising.

Now as we change one position for another, we judge ourselves not by the colleagues we have left, but by the new ones around us, and ultimately we find ourselves wanting. We findeveryone around us apparently performing better than we do, and we hang on for dear life, doing the best we can and fearful lest we be found out. Hardly a recipe for happiness. So the best advice I can give a graduate is beware of any promotion, lest it bring unhappiness.

Finally, the fourth ingredient of happiness, Purpose. I think a happy life has to be a purposeful one. Now that we know the scale of the universe, it seems to me the height of arrogance to believe that its creator (if it had one) is concerned with the affairs of the collective bits of protoplasm called Homo Sapiens on a speck of matter called planet Earth, particularly since we arrived so late and accidentally. If life is to have a purpose, it has to be a human purpose, and the sine qua non for such a human purpose is the preservation of the human species. I would also argue that the culture we carry with us, represented among other things by the music of Mozart, is also something whose preservation we should try to ensure. Hence the first condition of our activities is that we do nothing that brings the survival of the human species into question. I am afraid that we have not been living up to that condition very well.

At this point I wish to add my voice to the chorus about nuclear bombs and energy. I am possibly the only person here who saw both Hiroshima and Nagasaki within six months after the bombs were dropped. There was nothing much left of Hiroshima that I recall, except the shadows people cast on the sidewalks just before they were vaporized, preserved as a pattern of glazed and unglazed stone.

As we approached Nagasaki, we passed the Mitsubishi steel works at the north edge of town. They were a mass of twisted girders from which hung great drops of metal that had formerly been the corrugated iron roofing. There could have been no survivors. I vowed then never to have anything to do with nuclear energy or the search for uranium until the entire atomic enterprise was in the hands of a wholly international organization. Since that never came to pass, I have stayed out of the uranium search.

I started with the solipsist's dream, that all the world would die when he did. Unfortunately this dream has become a nightmare reality. The past thirty-five years of nuclear bombs and intercontinental missiles have made us steadily less secure, at least as much from the actions of the madmen on our side of the world as of those on the other.

But back to the pursuit of happiness. Can contemporary academic life enable us to catch it. Well, no, for another reason, the word Excellence. Many times the last few years I have been the recipient of memos from on high exhorting us that our major aim is the pursuit of excellence. I am

not sure that the users of that word really know what it means. It means being better than everyone else---being Number One.

Now imagine a hundred prestigious geology departments around the country, each obeying the single-minded exhortation of its college administration to pursue excellence. Well, obviously 99 of them are not going to be happy because they haven't become Number One; and Department Number One? Its members will be working their butts off to maintain their position and looking nervously over their shoulders to see if anyone is catching up. Hardly a picture of happiness. And academics have as much a right to be happy, I think, as anyone else.

So if you engage in research, don't engage in it merely for publicly acknowledged excellence. Engage in it for curiosity, perhaps, or for its demonstrable social benefits, or because it is fun. And avoid that which threatens human survival. And remember, those who work for a more equitable distribution of social benefits, now that we have to become a no-growth society, and those who work for and in a broad public education system, to make the enjoyment of knowledge available to all, are contributing more than those who merely do research, for on them depends the survival of society. And try to be happy. These are modest goals, a form of hedonism, which we have always been told is an ignoble philosophy. But any grander goal, I fear, is a dangerous delusion.