University of Sydney
Centre for Human Aspects of Science and Technology
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Biology as a Social Weapon

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The following is a transcript of the proceedings of the lecture and the following discussion. It has been lightly edited to remove obvious repetitions but has been otherwise left unchanged to preserve the informal nature of the talk, which was delivered without notes.

Introduction by the Chairman, Associate Professor James K. Beattie, Director of CHAST:

Welcome to the 1997 Templeton Lecture, to be given by Professor Richard Lewontin of Harvard University. The Templeton Lectures were endowed by the very generous gift of Professor Charles Birch who received the Templeton Prize in 1990 for his contributions to scholarship in the interface between science and religion. We are very pleased that Professor Birch is here this evening, to participate in the proceedings.

The lecture is organised by CHAST, the Centre for Human Aspects of Science and Technology, an organisation within the Faculty of Science and we are pleased that the Dean of Science is also able to be with us. In addition to this welcome task of organising the annual lecture CHAST is also involved in other occasional lectures; it organises or underwrites a number of other workshops and conferences in areas relating to its purposes and organises courses for students, on aspects of science which they might otherwise not encounter.

There will in fact be a workshop tomorrow morning organised by Professor Lewontin in the Old Geology Lecture Theatre. You are all welcome to attend. There are forms for registration down here. They will give us an idea of how many to cater for. That will be the second public appearance of Professor Lewontin.

Membership of CHAST is open to anyone associated with the Sydney University and we are looking for new members, new initiatives and new energy.

Professor Lewontin is perhaps the quintessential Templeton Lecturer given his contributions to the social aspects of science. His undergraduate education was at Harvard; he returned to his native New York City for his graduate degree at Columbia and then held a series of academic positions in various parts of the United States and Chicago. He was called back to Harvard in 1973 where he is Professor of Zoology. Those of you in the field will know of his many seminal contributions in that area, and those of us who read the New York Review of Books will know of his many other writings and efforts in commenting on the social aspects of science. He is continuing that effort here in Sydney in tonight's lecture: " Biology as a Social Weapon".

Professor Lewontin: This is really an intimidating audience. There is nothing more awful than to give a speech when nobody comes. But it is almost as bad to give a speech when so many people have come because you can't possibly fulfil that kind of expectation. And I was frightened to hear the chairman say that everyone is welcome to the workshop tomorrow. We will indeed have catastrophe, chaos and complexity if you all come along tomorrow.

I want to thank the Committee very much for having invited us back. It's been 35 years since my wife and I and our children spent a very happy 15 months in Sydney. It is with some trepidation that we will go back to look at our old house in Bronte in fear that we will find it replaced by a high-rise.

What I am going to talk about tonight, I think has resonance for Australians. It's the problem of the intersection between biology and what I would characterise, at least for North Americans and for many Europeans, as the central social agony of the last two hundred and fifty years, and that is the problem of equality. North Americans especially are absolutely obsessed by the problem of equality, and our history has had a civil war, urban riots, and major social reorganisations, all concerned with the problem of equality and I'm not terribly surprised to find on arriving in Sydney that some of that same uproar in occurring now in Australia.

The concept of equality is a central social agony because of what appears to be a contradiction between the political myths, embodied in political slogans on which our society is built, which we inherited from the revolutions of the seventeenth and eighteenth centuries and the reality of social life. In order to understand that, one has to go back to the situation before those revolutions that gave rise to our present society, to the seventeenth century and before, when one's position in life was fixed. People owed their position, essentially, to the Grace of God. And any major changes in social status (especially any large scale rising and falling) was seen as a result of the conferrals or withdrawals of Divine Grace. Charles I, as you will recall, was King of England, *Dei Gratia* and God's grace was removed from him, as Cromwell noted, the evidence of which was his severed head. That is to say it was indeed a case of the removal of grace.

The society which existed at that time was a society in which persons were not free to move in the social hierarchy. They were not able to sell their labour in the labour market. There was, in fact, a binding up of social relations. Indeed, they did not even have notions of contract law. If you made a contract with some merchant and you happened to be a monk, when you didn't pay, the merchant had to sue you in the court of your ecclesiastical superior. And if he, on the other hand, didn't provide the goods he had promised, you had to sue him in the court of his lord. But there was no common contractual understanding.

The revolutions which occurred in our society were a bid to overturn that set of static hierarchical relations. They were meant to provide a society in which there was free movement of persons. People would be free to sell their labour power, slavery and serfdom being abolished. We live in a society which is the inheritor of those revolutions that took place in France and North America and earlier in Britain. But in order to make a revolution, in order to change social relations, revolutionaries had to have a new source of political legitimacy because what was being done was that the old sources of legitimacy were being broken down. New people were coming into power and that legitimacy of Divine Grace had to be overthrown and new sources of political power had to be created. To do that, revolutionaries had to make slogans, because blood was to be shed. Those slogans were created by the fathers of the French and the English and the American revolutions, slogans like "Liberté, Egalité, Fraternité."

Every American child, (not every Australian child) knows by heart the claims of the Declaration of Independence: that all men (and I emphasize men) are created equal, that they are endowed by their creator with certain inalienable rights, and among those rights are: life, liberty and the pursuit of..... (and then there was some argument about what was being pursued. The Declaration of Independence

says “happiness” but Jefferson agreed that what really was involved here was money for that is the thing that gives happiness.)

The problem is that, after the revolutions established the societies in which we live, we didn’t have Liberté, Egalité, and Fraternité. We didn’t have equality. We had just as much inequality as ever. There were still after the revolutions, and are still today, people who are rich and people who are poor; people who have power over the use of their own labour and people who don’t; people who, from a million miles away are invited to come and give a lecture in this room, and then people who will come into the room after we’ve all left and sweep it up.

There are differences in power between men and women, between blacks and whites, between different classes. Those obvious differences in status, wealth and power exist and, by any objective measure, they are as great as they were in the 18th Century. There are different people who have the power but there is just as much inequality. The difficulty is that the slogans have not matched the reality. And one can claim that they were never really intended to. One can say “Well look, you can’t make revolutions with a banner that says “Some people are sort of equal”, so you make claims that necessarily exceed your intention. And they certainly did exceed intentions. Slavery still existed in the French dominions long after the French revolution and the same was true in the United States. In the US, when they said that all men were created equal, they meant literally men, of course, until quite recently, and they didn’t mean all men. It is stated in the Constitution of the United States, that black men were only three fifths of a person. We actually have it numerically!

So one tends to be a bit cynical. But the point is that there is a constant apparent contradiction between the slogans that claim to be the basis of our meritocratic society, and the observed facts. So what do we do about it. You can say: “It never was meant to be equal. It’s all a sham, a device. Some group got power and is using those slogans to retain power”. If you believe that and at the same time you want a society of real equality of status and power, you only have one choice in the matter: you have to make another revolution. But this is not a popular doctrine, at least among my colleagues in Harvard, nor at Sydney University, I suspect. If you really want a society of equality then stop talking about it and do something. The other alternative is to say, “People were serious about it.” To give them credit they did create a society which provides as much equality as can be provided. They succeeded in maximising the social entropy, if I can put it that way. What is really going on is that we abolished the artificial inequalities of the ancien régime and what is left in their place are the natural inequalities between individuals. We have created a society in which each person can move freely, not fettered by the structures of the society itself. And the manifest inequalities between different individuals, between races, between sexes, are themselves a consequence of the irreducible natural inequalities.

If you think that I made that up, I’ll give you one of several quotations so you will know I didn’t just make it up out of my head. I didn’t make up the claim that the bad old days were days of artificial inequality but now we have natural inequality. Let me read you a statement from my former colleague, now deceased, Richard Hernstein, who wrote a very important book called *IQ and the Meritocracy* and who was one of the major ideologues in this field. What Hernstein wrote is the following:

> “The privileged classes of the past were probably not much superior to the downtrodden, which is why revolution had a fair chance of success. By removing artificial barriers between the classes, society has encouraged the creation of biological barriers. When people can take their natural level in society, the upper classes will, by definition, have greater capacity than the lower lasses.”

So there’s the argument laid out for you. In the bad old days of the ancien régime the *aristos* had artificial power in the race of life. By the way, Jensen, another ideologue of this sort defines that race in this way:

> “The race of life is not to get ahead but to get ahead of somebody”. He says: “Heredity is the

chief determining factor".

So in the bad old days the *aristos* had an artificial advantage in the race of life. They already started at the finish line and we were right back at the start; we had fetters on our legs; we had poor running shoes, and what the revolutions did was to start us all off at the starting line together. The gun goes off and we run the race of life and, of course, some of us get to the finish line sooner than others. As in any race, the first ones are those who have better ability to run the race. It's an internal property of individuals.

This is the current ideology, namely, that we live in an equal opportunity society, not an equal status society. We have different abilities. Some of us have the ability to fill this room and can talk extemporaneously for a time, and others of us can only wait for a free lunch. But that notion is not newly invented. It was the notion that consumed the 19th century, and it has persisted. One can only understand the literature of the 19th century if one understands that claim. Let me give you a couple of examples from your favourite authors. Take Charles Dickens, the greatest mystery novelist in the English language. Oliver Twist, for example, presents us with the model for all this. Remember the story of Oliver. He was born in a workhouse, the most degraded institution of the old Poor Law at the beginning of the 19th century. He has no education. He spends his time rolling around on the floor, as Dickens says, with other "offenders against the Poor Law". He is occupied picking oakum; he has no mother or father to tend him. He has the poorest possible environment. He meets on the road to London the Artful Dodger, who has had exactly the same kind of life experience, living in the slums of London and we have the confrontation between the two types. The Artful Dodger drops all the g's at the ends of his words. He can't use good grammar. He's described by Dickens as having a snub nose and a distorted face, and generally his conversation is what you would expect of a boy of the street. Then we come to Oliver who is described as a gentle, delicate child. His grammar is perfect. He even uses the subjunctive. How many of you use the subjunctive? He has only the noblest sentiments and he is the hero of the book. So what is the mystery in all this? The mystery is explained at the end of the book. It is that Oliver, although he never saw his mother or father, is the child of middle-class parents *and blood tells*. It is a classical adoption study. The classical adoption study takes children from different natural parents, puts them in the same environment and sees how blood tells.

George Eliot wrote a great novel in *Daniel Deronda*. You should all read it. Daniel Deronda, we are told, is the stepson of an English baronet. He spends his early youth gambling in casinos in Germany and so on, and then mysteriously, at the age of his majority, he falls in love with a Jewish woman. Remember this is the first part of the 19th century. He gets interested in the Torah and Talmud; he becomes a Zionist and goes to Palestine. How can that be? The mystery is solved at the end of the book when Daniel Deronda discovers, and meets for the first time, his mother who is a famous Jewish actress. All of that stuff was in him and just had to come out.

This attitude was not restricted to Anglo Saxons. Among the most popular writers in France in the 19th century was Emile Zola, and Zola himself tells us that his novels are nothing more than the fictional working out of the laws of heredity. The mother of Nana, Gervaise the laundress, has pulled herself up from the depths; she has a business which is going well and then Zola tells us that one day when her arms were immersed in the laundry and the odours were rising, her eyes glazed over, a lassitude overtook her and she reverted to type and became the ne'er-do well of her ancestry. I'd like some day to give a whole lecture on the literature of the 19th century because it is the literature of this notion that *blood will tell*.

We don't talk about blood any more; we talk about genes, but it's the same thing. Genes are the modern form of the doctrine of grace. Geneticists don't believe in the doctrine of works they believe in the doctrine of grace. Either you are born with a good constitution or you are not. If you are born with a good constitution, you are smarter, more sensitive, more acquisitive.... And if you are born with a bad constitution then you go to pot. And if that isn't the doctrine of grace then I haven't encountered

it.

Now what I want to claim is that this view, that the internal state of the organism is what determines it, is part of a general ideology which has been brought up in a scientific way since the beginning of this century but was previously part of folk tales, linked with notions of 'blood' and that that ideology has three points.

The first point I have already given: that the differences in status in society are a consequence of in-born differences between individuals in ability and temperament. Some people are responsible, because that's in them, and some are irresponsible. Some people understand property rights and some don't. But that's not enough because it is not enough to say that we have different intrinsic abilities. If we really have a meritocracy, then people will rise depending on their abilities, but there should be no similarity, in social position, between parents and their children because the merit is just sort of there. How is it that there is a passage of social power from parents to children, if it's a meritocracy? If we have got rid of the hereditary aristocracy, why are we absolutely certain that the children of Nelson Rockefeller would be rich rather than poor? It can only be that that merit which is based on in-born ability must be passed on from parent to child. That is to say it must not only be in-born, it must be in the genetic substance; it must be *in the genes*. And don't confuse those two things, because there was a theory of in-born temperament which didn't talk about heredity. It just arose anew in each generation.

We want to explain the lack of perfect social mobility, and social mobility is a great deal less than is often claimed. If you look at the classic studies of social mobility by Duncan and Blau, for example, most blue-collar workers have blue-collar worker children; most white-collar workers have white-collar worker children and professionals have professional children. Of course, there is churning. Everyone in this room can say "Well, what about my kids?" But it's very far from random, and there is a passage of social power and that passage of social power must be in the genes. Where else would it come from if we are in a meritocratic society? But even those two claims (that success depends on what's inside of you and what was passed to you in the genes) are not enough to justify that system because I could always say "Of course there are some differences in ability. Some people can cut hair and other people can be surgeons, but why don't we simply reward everybody equally? Why don't we have a society in which the difference in status is not reflected in gold." To coin a phrase "To each according to his need and from each according to his ability". And for that this doctrine has an answer which is that it's utopian. I think everyone in this room thinks that it's utopian. But the reason it's utopian, according to this view, is that although we differ genetically from one another in our ability we all have a common genetic heritage which gives rise to what's called "human nature". We have all, in the process of evolution from our ape-like ancestors acquired a set of characteristics that create human nature and one of the characteristics, according to these nature ideologues, is we will necessarily build hierarchical societies, based on differential ability. Chimpanzees do it, and mice do it, birds do it and so, why shouldn't we do it? It's an evolutionary consequence. And if you link those three things together:

(a) that there are differences that are intrinsic which account for inequalities;
(b) that those differences are inherited through the genes, and;
(c) that those differences in ability will always be manifest in a society of extreme inequality because of the nature of human nature which itself is genetic.

Then you have a very tightly argued theory.

I will call that theory, and have previously called that theory, the *Doctrine of Biological Determinism*. It says that the structure of society is determined biologically, and there is nothing you can do about it. So you might as well relax and enjoy it. And I remind you of what Mr Hernstein said: Because the privileged class in the past were not biologically superior to the downtrodden, revolutions could succeed. But the implication, which he doesn't say, is that now that the differences are biological, revolutions can't succeed. I don't really know whether the theory of political science predicts that the biologically superior society can never be overturned whereas the socially superior one can. Maybe

there is some law of politics there.

The doctrine of biological determinism is used over and over again in universities and schools, in the press, in public relations, in books, as an explanation of our society, but it is also used as a quite deliberate weapon in the social struggle (and that's why I entitled this talk "Biology as a Social Weapon"). It doesn't matter what your politics are: left, right or middle, you'll recognise that there has been in the history of all the civilisations we know of, a constant struggle between those who have and those who don't have. Those who don't have want to have, and those who have, want to keep it. That has been manifest in peasant revolts in Europe, in China, in North America and in all kinds of armed struggle. And those who have power must use violence to retain it. But nobody wants to live in a society in which the struggle between the haves and have-nots is a violent one, because nobody can enjoy the "pursuit of happiness", even those who have it, if there is violence. So we have an elaborate system of struggling over who has what and why, which does not involve violence but which involves social institutions that are supposed to replace violence: courts, laws, consensual agreements, and so on, but in addition we have education.

One of the functions of education is precisely to convince people that the world in which they live is pretty much the world in which they have to live. I will end my talk with a wonderful quote from Daniel Webster, a reactionary American politician from the early 19th century, of whom none of you has ever heard, but which expresses that point very clearly. Indeed it is a very important function of education to put into people's heads the notion that if you don't like the way things are there is nothing you can do about it. Because the other notions lead us in fact to violent confrontation, to constant struggle. So that's why I say that the Doctrine of Biological Determinism is a social weapon. It's a weapon in the constant struggle between those who have and those who don't have and, of course, that weapon is in the hands of those who have. They include Professors at Harvard, and I'm going to try to convince you that professors in major universities and major intellectuals in North America have been among the chief creators of that intellectual apparatus which is used over and over again in the press, the universities and the schools.

But before I do that, since this is supposed to be a lecture with some biology in it, I want to claim that that ideology, namely that human beings are essentially determined by what's inside them, is very bad biology. It does not correspond to what biologists know about biology and, therefore, whether you like or dislike the ramifications of this proposition, you shouldn't believe it. If you like it, you'd better find another justification because this one is wrong. If you don't like it, you have plenty of ammunition in the struggle against it.

What I want to talk about is how organisms really are formed. I want to begin by saying that we are not determined by our genes. No organism is determined in its totality by its genes. Geneticists believe that we are formed by our genes. Sid Brenner, one of the most famous molecular biologists, once said at the hundredth anniversary of the death of Darwin:

"If you give me a large enough computer and the complete DNA sequence of an organism, I could compute the organism."

That's what it means to say that genes determine the organism. I want to convince you that that is rubbish. Sid couldn't do it, because no organism computes itself from its genes. That's not the way organisms are made. My colleague, another very great molecular biologist, Wally Gilbert, has said:

"When we have the complete sequence of the human genome, we will know what it is to be human."

I can only say whether you like the sound of that or not, it does not correspond to what we know of the role of genes in development.

The truth of the matter is that every organism is a unique outcome of a complex interaction between the genes that it acquires in the combination of sperm and egg, the complete sequence of environments through which it has passed in its lifetime and, in addition to that, very important random factors in

internal cell metabolism that have a non-trivial role to play in determining what the organism is like.

I want to try to convince you that the right way to think about organisms is not that they are determined by their genes, nor by their environment, but that characteristics of organisms are the outcome of a very complex life-historical process in which genes are influential, to different degrees depending on the trait, in which environment is influential, again depending on the trait, but that it is not just a matter of adding one to the other. They are in unique interaction with each other and it is often impossible to make any predictions about what will come out. And in addition there are important random factors.

To this end I want to show you a very famous picture (Fig 1-8). It's a picture of the outcome of a cloning experiment. Cloning is old stuff in biology; it's easy to clone some plants. All you need do is take some scissors and cut them into pieces and plant them and they grow up into new plants. People have been doing that for a very long time. I am going to show you a picture of an experiment in which plants were gathered from nature. They were cut up into three pieces. One piece was planted at a low elevation, one piece at an intermediate elevation and one at a very high elevation, in the Sierra Nevada mountains in California, and that was done for a sequence of plants.

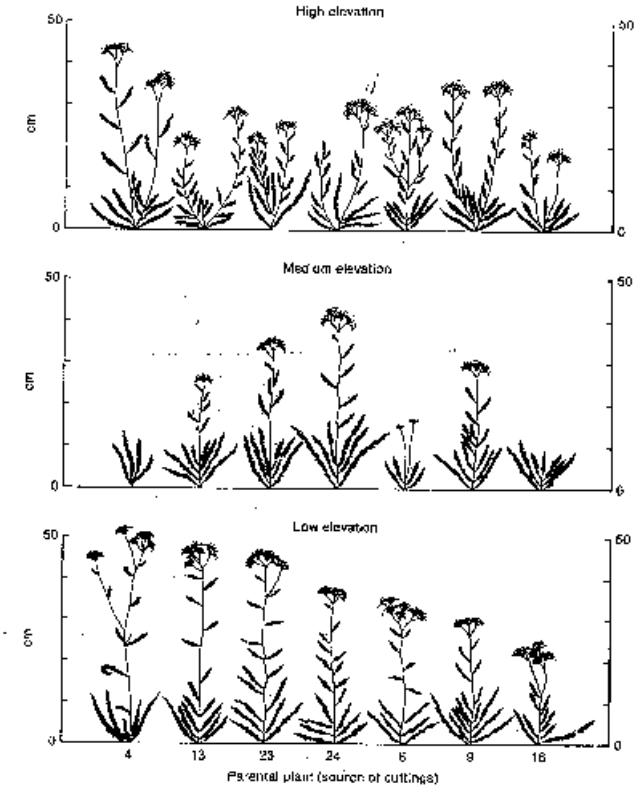

Figure 1-8. Norms of reaction to elevation for seven different Achillea *plants (seven different genotypes). A cutting from each plant was grown at low, medium, and high elevations. (Carnegie Institution of Washington.)*

This picture is taken from a very large study done by Clausen, Keck and Heisey on a plant, Achillea. There are hundreds of such pictures from which I have chosen one, truly at random, from the volume. Here you have seven plants, ordered by their growth from the best grower to the worst grower, at low elevation. The second line shows the exact same plants (genetically) grown at an intermediate elevation. So the three plants one below the other are clones of one another. You will notice that the best grower at the lowest elevation is the worst grower at the intermediate elevation and it's the best grower at the highest elevation. The second best is fourth best at the intermediate elevation and the second worst at the highest elevation. There is no obvious relationship between how well they do at the lowest elevation and how well they do at the intermediate and highest elevation. In fact, if you actually measure the plant heights here, there is no correlation at all.

Let me ask you the question: "Which set of genes makes the plant the best grower?" You can't answer the question. You can only answer the question if you are told in what environment the question is being asked. There isn't much average effect of environment here, although this lower level environment is better for these plants, which were taken from a low elevation. The highest elevation is, on average, second best and the intermediate environment is worst. So there is some average environmental effect but it is not very large and there is no average effect of genotype at all. So what is important here is neither the environment nor the genotype, nor some summation of the average environmental effect and the average genetic effect. It's not that the worst growing plant is the worst genotype in the worst environment, although one is pretty bad, because the best genotype in the worst environment is also the worst in another environment. What you've got is a unique

interaction between the particular environmental circumstances, and a particular genotype in determining the overall response. And that is a typical, although not universal, result.

Take the matter of different eye colours. You don't just have blue or brown eye colour but a large number of different colours and, as far as we know, the eye colour of everyone in this room is entirely determined by their genes. I can't prove that, but to the best of our understanding, there are many genes influencing eye colour and the variation we see is genetic.

On the other hand the people in this room do not all speak English identically but I can assure you that our genes have nothing to do with the phonemic structure of our speech. After a year of living in Sydney I sounded a great deal like an Aussie. And those of you whose ancestors came here from Central Europe, or the Mediterranean, or India, I'm finding now speak Australian just like anybody else. So characteristics of individuals can be entirely a function of their genes (as in the case of eye colour), entirely the consequence of the social milieu in which they were brought up (as in the case of phonemic structure and how many diphthongs and how many triphthongs you have in your speech). But the typical characteristics of experimental organisms (we don't have very good information about people) is more complicated, and this is true whether you are talking about plants or fruit flies.

I want to show you one more picture to try to nail the point home. **[Insert Fig 2]**This shows the results of an experiment in which genetically different fruit flies were grown at different temperatures. What is shown on the vertical axis is the probability of survival of an individual from a laid egg to an adult fly (including the viability of the larvae) and you see that there are some that really are miserable. They die in all three environments, so they are genetically very bad. But then you have one like this, which is good at this temperature, quite poor at this temperature, and back up again at this temperature. And in fact, if you take these extreme genotypes, as being more or less unaffected by environment, as one group, most genotypes in natural populations go up and down they cris-cross each other. You can't pick out the type that has the best probability of survival. It depends on which temperature and that's what most characters look like. So the proper way to describe how organisms develop is not to say: if I know their genes I know what they are.

Let me show you some alternative schemes, that I could talk about. The first scheme here **[Insert Fig 3]** is the scheme of genetic determination. There are different environmental factors but they go into a box which involves either genetic plan A or genetic plan B. If they have genetic plan B they become organism B; if they have genetic plan A they become organism A and genes really make the difference. Genes take in environmental influences and determine outcomes. Now I claim that that doesn't work for most characters and most organisms, even though it works for eye colour.

Here's another system **[Insert Fig 4]**. There are different environments, there are general genetic rules like the ability to speak at all, grammar and so on, but whether you speak American English, Australian English or French or Hungarian depends entirely on the environment in which you were brought up. That's the language model. Now I want to claim that that is not descriptive of most of what goes on in the world, although in the case of language, obviously it does.

The model I have been talking about is this one here **[Insert Fig 5]** which shows that there is a unique interaction between genotype and environment. Here is genotype A. In environment 1 it makes an organism AI, whilst in environment II it makes an organism AII. And in the case of environment III it makes another type of organism and you don't know what the organism is going to look like until you observe the different genotypes operating in different environments. It has no predictability. In American law, if you ask a lawyer a question he always gives you the same answer: "It depends on the jurisdiction". Likewise for characters of organisms it depends on the jurisdiction.

Now this is not the complete story. There is a third factor besides genotype and environment which has an influence on what organisms look like. That factor is the existence of random events that occur in cell division and the movement of cells in organisms and they may have very important effects on what organisms look like. For example, fruit flies, which I and other geneticists have studied, have big

hairs which stick out under their wing pits. These are sensory devices which are very important to the fly. (They are not just like the hairs on your head.) You can count them and the number is not the same on the right hand side and the left-hand side of the fly. Some flies have eight on this side and fourteen on that and others have four here and nine here. On the average there is no difference between sides. On the average they are not hairier on the right than the left but each fly has a different number. This is called fluctuating asymmetry. And these are not trivial characters in the life of a fly. Now the genes on the left hand and the right hand side of the fly are identical and the environments in which those left and right hand sides developed were identical. Fruit flies are the size of the end of a lead pencil and the flies whose bristles I counted grew up stuck to the inside of a glass bottle so there is no average difference in their environments.

We know something about how these bristles are formed. I don't have time to tell you the whole wonderful story but essentially what it comes down to is that it requires several cell divisions and the movement of cells from the inside to the outside of the organism. And that has to go on at the right rate, before the external surface hardens or the cells will not arrive in time to form a bristle.

Another example: the fingerprints on your left and right hands are not identical. They are very similar but not identical. You're not symmetrical. There are those well-known photographs in which you take a person's left or right half face and flip it to form a complete image and they look quite different. There are all kinds of fluctuating variations due to random events.

Most biologists are familiar with what happens if they take a very large vessel of bacterial culture medium and put a single bacterial cell in it. After about an hour it divides into two cells, but an hour later those two cells don't suddenly go bop!! And then an hour later those four cells don't simultaneously go bop!! On the contrary, there is a variation in the time each cell takes to divide, even though there isn't enough time for mutations to occur, even though they are floating around in this immense sea of homogeneous medium.. And that's because, in cell division, random events occur in the partitioning of molecules which are present in small numbers in cells, and cells move from one state to another as a consequence of these random events and we don't know how important these random events are going to be.

One of the most trendy modern theories on the development of the human central nervous system, the so-called neuronal selection model, pushed by Gerry Edelman, which certainly has important elements of truth in it, says that a large number of neural connections is made in the development of an organism like us and they are made at random. Then there is some selection among those random connections so some will be made firmer and carry on and the rest will be lost. So the importance of random connections is apparent. I mean, I wish that I could play the violin as well as, or better than, Yehudi Menuhin, but I can't and I am absolutely certain that if I had started to learn to play the violin when I was three I still couldn't play it that well. I am sure that the young Menuhin had neural connections that I don't have. But that is not the same as saying that those neural connections are the consequence of his having genes that I don't have. There are a lot of physical differences between organisms that are consequences of growth patterns in development which are not determined by genes and not determined by environment.

So the grand finale of all this is shown on this picture **[Insert Fig 6]** which is the last one I'll show you. That's the real picture of the determination of organisms. Each organism has genes, and it goes through some development but that development is a noisy development, if I can put it that way, a consequence of random cell division patterns. So even in the same environment, the same genes don't give the same organism. And the importance of that random noise, the importance of genetic differences, the importance of the environmental differences, changes from character to character and species to species. The problem for biologists is that they wish they were physicists. My wife reminded me today that I used to say "Biologists suffer from physics envy". They would like it to be a world in which there is a very small number of easily measurable forces and the result is you can know in which direction the projectile will go. But it's not like that for biological organisms, not because there is some

mysterious entelechy behind them, but because they are the nexus of a very large number of weakly defining causal pathways and they are intermediate in size and internally heterogeneous, and so its a mess.

There are no laws of biology and don't let anybody convince you that there are. Even Mendel's Laws are not laws. They are the description of a little machine that operates inside the cells and we have a lot of examples where Mendel's Laws don't apply. Cells do terrible things. They do not distribute their chromosomes in accordance with Mendel's Laws. Lots of times, most of the time, they do, thank God, but we know many cases where they don't.

We have biological generalisations but we have no biological laws. The only law we know of which is completely universal at the present time is that all life comes from life. But that is a law that was passed only relatively recently. If it were a universal law like a law of physics, that all life came from life, we wouldn't be here because we had to start from somewhere. So there was a time when non-life gave rise to life. Whatever your story is about that, that's your story but it happened once. And indeed if we should stumble across a place, some boiling sulfur stream, in which life was being produced out of non-life, we wouldn't say "Oh, my God, what an entire restatement of biology this is going to require." No. We'd say "Wow!! There is still a place on earth which, by sheer luck, has got the conditions that existed once a long time ago. And we'd all rush down to study it because we know that used to happen, and now we've found a place where it is still happening.

I say that all biological laws are historically contingent generalisations and they apply to some group of organisms. My purpose in telling you all this is to try to convince you that good biology, biology that all biologists know, tells you that genes don't determine the organism. Yet molecular biologists continue to say that DNA is self-replicating. Everybody in this room, even if they are not biologists, will have heard that DNA is the master molecule that it replicates itself. It's like the Holy Grail which reduplicates itself. The only difference is that the Holy Grail was only able to do that on Good Friday whereas we do it every day of the week. But there is no self-replication. That's a lie. I made these slides by taking a piece of paper and going to the Xerox machine and turning on the machine and copying them. Do I call that self-replication, when I have copied a pre-existing piece of paper? DNA can't self-replicate. DNA is manufactured by cells. It is manufactured by a very complex machinery in the cell, with enzymes and energy inputs. In that factory for DNA it takes the old DNA and uses it as information to produce the new one but it is a copying process, not a self-reproduction process, just like a Xerox machine is a copier, in which the piece of paper does not self-reproduce. And it is very important to understand that the claim that DNA is self-reproducing is a pure piece of propaganda which every molecular biologist knows is not true.

We've spent a long time working out the way that DNA is manufactured by the cell. I say it's propaganda because by saying it that way it reinforces the notion that genes dominate our lives, that they are the master molecules. Not only are they saying they are self-replicating but they say that genes 'make everything'. But genes don't make anything. Genes are very inert chemicals. They don't engage in chemical reactions. The cell uses them in a very complex process which examines the gene and manufactures all its parts after having consulted the gene. But the genes don't do anything. They just lie there. The real machinery is the machinery of the cell. And it is very important to have some linguistic cognisance of that because it all feeds back over and over again to the claim that we are dominated by our genes and that is just not true. It's bad molecular biology; it's bad developmental biology; it's just bad science.

So we come back to the question I started with: if it's such bad science, how come all those famous scientists keep saying it? I guess it's how you see yourself advancing your career. You study things that are easy to study, like genes that make a big difference. You don't study messy genes. People who study messy genes like the ones in Figure 1 don't win Nobel Prizes. Science is the art of the soluble. That means that smart scientists first figure out whether they can get a simple answer before they even

start work on the problem, because if you can't get a simple answer you're going to fail.

But I do want to emphasise that it is professional scientists, professional intellectuals, people who are supposed to know, professors in universities, heads of museums, who are constantly telling us these things over and over again and that has been true in the 19th century and the 20th century. Mr Hernstein was Professor of Psychology in my university; Arthur Jensen was a professor at the University of California, Berkeley, but we don't have to think of them. We can go back to even more famous professors.

I want to give you a couple of other quotes from famous professors to convince you that people have been saying this kind of thing at its appropriate time even though what they said was bad science at that time. One of the most famous biologists of the 19th century, Louis Agassiz, was an anatomist who claimed that the skull sutures of black babies close much earlier than the skull sutures of white children. So the skull becomes rigid when it is still fairly small and therefore you can't teach them much because the brain doesn't have room to expand. It was rubbish, literally. He said it as if he knew it. He claimed it to be true but he could not have observed it. He used his authority as a great zoologist to tell people that it was the case. Let me give you my absolute all-time favourite quote, from the man who was the Director of the American Museum of Natural History in New York, the man who worked out the evolution of the horse, Henry Fairfield Osborne, one of the great palaeontologists of the first half of this century. He wrote in the New York Times (talking about the evolution of various European groups or races - there's an "Italian race" and a "Swedish race")

"The northern races invaded the countries of the south, not only as conquerors but as contributors of strong moral and intellectual elements to more or less decadent civilisations. Through the Nordic tide, which flowed into Italy, came the ancestors of Rafaello, Leonardo, Galileo, Titiano, and also, according to Gunther, of Giotto and Botticelli, Petrarca and Tasso."

How he knew who the ancestors were I don't know.

And now, for an American the best of all: Columbus. I want you to listen very carefully to this sentence:

"Columbus, from his portraits and busts whether authentic or not was clearly of Nordic ancestry."

It is a well-known fact among historians that we don't have an authentic portrait of Columbus. Now here's a guy who would not write a paper about fossils in which he said "I have reconstructed the fossil history of the horse based on some bones I dug up, whether authentic or not." But he is using his authority to say things to people about human genetics and the origin of differences and why the Italians produced such wonderful poetry and so on which is just rubbish. And he is not some street corner demagogue; he is a person speaking from a position of very great power. Just like Hernstein, just like Jensen, just like Professor Agassiz. It is extremely important to understand that universities and intellectual circles, like newspapers and radio stations which interview professors, and report what they have to tell you, are creating an ideological apparatus which is a very powerful thing. They are engaged in an educational enterprise the purpose of which is to convince you all that the world in which you live is inevitable, and maybe even fair. I don't know about that last, but certainly if it's not, there is not much you can do about it.

A former Professor of Education in the US, Frank Freeman who was an eminent sociologist put it this way:

"It is the business of the school to help the child to acquire such an attitude towards the inequalities of life, whether in accomplishment or in reward, that he may adjust himself to his conditions with the least possible friction."

That's what schools are for. That's what Mr Freeman says. He was the father of modern educational practice, at least for my generation.

I'll give you two more quotes and then I'll shut up. One is from a school textbook in use in the State of Illinios in elementary schools. It says:

"What did we learn today? We go to school to learn about people. We learn that people look different. People speak different languages. Some people have more than others. Some people have less. Some people know more than others. Some people know less. Some people can learn a lot. Some people can only learn a little."
So the complete syllogism is offered to the school children: Some people have more, some people know more, some people can know more.

I'm trying to convince you that I didn't make this all up out of nothing; this bad spirit permeates the literature of education. And finally let me come to my last quote which is from this famous reactionary politician, Daniel Webster who came from New England. He was really somewhat to the right of Attila the Hun so like some people he was a radical reactionary. And that means he was not afraid to say what he really thought. He said

"Education is a wise and liberal form of police, by which property and life and the peace of society are assured."

And we have just been engaged in such an education.

Discussion on the Templeton Lecture 1997.

Question: Why aren't identical twins less alike?

Lewontin: Identical twins are alike in some respects and not in others and in the different respects they are alike to different degrees. Their fingerprints are not identical but they are very similar. They'll have the same eye colour; they look alike, that's how we recognise identical twins, but it is also the case that, for most identical twins, an immense effort is put into making them as alike as possible, in a whole variety of characteristics. Many identical twins are given names beginning with the same letter, they are dressed in identical clothes, their hair is cut identically, and they are given identical toys. In the US there are 'Twin Olympics' in which twins are brought to a kind of grand County Fair and prizes are given to those who seem most alike in every respect.

But sometimes they confound us. When I was a child the most famous identical people were the Dionne quintuplets who were genetically identical. They were taken by the Province of Ontario away from their parents, they were shown off to the public, all dressed in identical clothes, identical hair and so on and so forth and every attempt was made to make them as identical as possible. But they confounded their handlers. One of them died of epilepsy, at the age of 20. One died at about 36. Three are still alive. Two tried the religious vocation but only one succeeded; two became nurses, three had children and two didn't. They had lives which were really rather different. Each one, one might say, was unhappy in his own way. (Laughter).

What I'm trying to say to you is again what I said before: I'm not surprised that identical twins have the same nose shape, but it's not identical. It depends on how closely you look, and remember that our appreciation of the tremendous similarity of identical twins has to do with our learned perceptions of how we recognise people. They may look alike to us. I have always been amazed, and it's a very interesting question, at the fact that identical twins who have identical genes look identical but full siblings who share half of their genes, generally don't look at all alike. So it's not a linear relationship between how many genes you have in common and how similar you look. I know lots of brothers and lots of sisters whom I would not have guessed had half their genes in common. So there is something there to do with the cues we use to identify people. My wife and I were once in Egypt, a long time ago, and some Egyptian man came up to her and started to talk to her in a hotel. And my wife said: "I'm sorry, you have the wrong person." And he stepped back and said the equivalent of: "I'm terribly sorry, but you all look alike to me". (Laughter). It is clearly a question of perception.

So you're right. They are identical in many things , for example in eye colour, but they are not identical in their performance in life, if you give them any chance not to be.

<u>Question:</u> The big debate in Australia in the last few years has been about racism and your work has clearly been about getting the science of race straight. When was the first time that science tried to make some justification for racial discrimination?

<u>Lewontin:</u> Well I gave you Louis Agassiz in 1850, but you can go back to DuFont. European scientists have been conscious of race since before they were called scientists. They were natural historians. The English naturalists of the 17th century were conscious of the existence of Africans, Chinese. The word race is a very sticky one because race means essentially stock. When we talk about 'the last of his race', what do we mean? Or people talk about the Irish race. Or they talk about the black race. The word race has changed its meaning a lot in history.

But there has been a change within science. When I was a student, race was a very important part of

the consideration of anthropologists . There were anthropology textbooks and curricula, and anthropological researches conducted on differences between races. Anthropologists don't talk about race any more, only as an interesting historical notion. Race does not lie deeply in the heart of anthropological theory. So the question of race has been de-emphasized.

My own work on this subject, which is a statistical summary of work in the literature, shows that about 85% of genetic variation in the world is between individuals within the same local population - the differences between any two Irish or between any two Wik people (to choose a group at random). Of the 15% that remains, which is between groups, about 7-8% of that is between local groups in the same so-called race. That is between Irish and Italians and Spanish and French. And the other 7-8% is between the major races: black, yellow, brown and white. Those studies hold up pretty well using more recent data on DNA, so that is a firm result. But the answer to the implicit question is that doesn't prove that the 7% difference between those major groups might not include any old gene you want to throw in. There are no rules. So I am talking about statistical averages but I don't know anything about traits. And that's quite important.

Question: A theory which had an airing in a book review recently concerned the (supposed) correlation between brain capacity and IQ and I remember seeing examples of this in the Victorian exhibition in London in the Museum of the Royal Society . I was interested to see this Victorian idea coming back again. What's your view of that?

Lewontin: Yes. It comes back over and over again. There are papers published quite recently, and frequently, which claim to show a relationship between cranial capacity and the performance on IQ tests. It's not a startling correlation and, of course, you can always tell anecdotal stories e.g Anatole France had the world's smallest brain, Einstein's brain was not very big. I think what is going on there is something different. It's an attempt to put a concrete anatomical underpinning onto the notion of intelligence which is a very badly formed notion. We have IQ tests and we can talk about intelligence tests. For all I know there is a correlation and a perfectly correct correlation, between brain size on average and performance on IQ tests on average. You certainly couldn't pick out in this room the person with the highest recorded IQ but you could pick the person with the biggest head. So it's one of those attempts to put some anatomical firmness under a vague notion.

Having said that, I want to make my own position very clear. I think performance on IQ tests must have some influence of genetic composition, because I believe that everything that every organism does must have some influence (I emphasize influence) of the organism's anatomical structure, which in turn has some influence of genes, but that is not the same as saying that there are genes for IQ.

Let me tell you a story. We know from studies of rats (and I don't like animal models) but this suggests a story, that there are what are called 'maze-dull' rats and 'maze-bright' rats. Some rats can run a maze very well and some do very poorly, and that is a true breeding difference. One can grow strains of dull and bright rats. It turns out if you look at these, that the maze bright rats have light coat colour and very light eyes and if you give them neurological tests, the maze bright rats turn out to be partly deaf and partly blind and the reason that they are maze bright is that they don't get distracted. (Laughter.) I don't mean that as a humorous comment. So how about that as a model for the genetic component of IQ? I don't know how Australian children do their IQ tests but, when my wife and I did the test, we did a written test. My written test was done in a class with a lot of other children. We were about 10 or 11 years old at the time. The light was streaming in the window, there were voices, the kid next to you hasn't had a bath lately, there is a lot of sensory input, and the task is to give answers to context-less and meaning-less questions. They are just random questions. I can assert that if my sight is good enough to see the pages, but I'm not conscious of all these inputs, including the olfactory and auditory inputs, I could imagine doing much better on the IQ test.

So there is a model for IQ performance but it is not one we care about. I tell this silly story because I want to emphasize that there is a vast difference between saying there are genetic differences which have an influence on a characteristic and saying that there are genes for the characteristic.

As biologists, what our interest must be is in the mediation. What are the physiological and anatomical pathways by which genes have an influence on traits. To give you the one I have been purveying to my friends lately, there are genes for knitting. How do I know that? Because nearly everyone who knits has two X chromosomes. (Laughter) and few of those who knit have a Y chromosome. So there must be genes for knitting on the X chromosome. And it is certainly true. There are genes on the X and Y-chromosomes which have a very important role to play in determining your plumbing, and depending on the nature of your plumbing, you're sexualized in a particular way. And the socialization of one form of plumbing is to knit and the socialization of the other form of plumbing does not permit you to knit. That's the mediation and it is important, because up until the middle of the 18th century, that story would have had to have been reversed. Because hand knitting was done by men, as it still is in some islands off the coast of Ireland and Canada. Hand knitting was a commercial enterprise, and men did it, as they always have done what brings in the money. And when the knitting machine was invented, men went into factories and looked after knitting machines, and hand knitting was handed over to women as being less important. I like that story because it gives me historical contingency, and full mediation for explaining why there are genes for knitting.

So now I say, there are genes for IQ. What's the mediation? How do those genes act in such a way as to make it possible to answer those short answer questions? I don't know. And it might be just as silly as the genes for knitting.

Follow up question: The figures produced in this Victorian exhibition said that the average male brain capacity was 1300ccs, if I remember correctly, and the average male aboriginal brain capacity was about 1100 ccs and female aboriginal 700 ccs, and European female was also only about 1100 ccs.

Lewontin: There is, of course, a correlation of cranial capacity with total size, and it is true that the average cranial capacity of women is smaller than the average cranial capacity of men, when not corrected for body size. You have to correct for body size. Not only the Victorians but the present Victorians have failed to take that into account. If it's true that women have smaller brains than men then how come they're smarter? (Laughter.)

Question: Can you comment on (i) the political context of the current fashion for genetic engineering and (ii) the fact that the human genome project is funded by the US Department of Defense.

Lewontin: Why is it funded by that agency? Is that what you wanted to know? Let me answer that question first because it is easier. In my view it has nothing to do with any military implications. It is not done because the army thinks it will lead to better biological warfare. What you see is a manifestation in the American polity of a struggle over influence in general on research. Where money pops up for research depends on the political state of your organisation. I, for many years, was supported by the Atomic Energy Commission to do my research , but they never asked me to do anything for them. They just asked me to take the money. And they would write letters and say: ? Look we haven't had your grant proposal yet. We've already put aside the money; would you please send us a proposal.? (Laughter.) I stopped that when I was told that they couldn't pay me as they had been doing because now there had been a high level decision that the most trendy research would be

the human genome project, and that's what they wanted me to compete for.

What you have here is governmental institutions which have a long life and it's not because they have a mission. One shouldn't look for conspiracies where there are none. That's my answer. It might be wrong; there might be some hidden agenda but I can't figure out what it is.

On the first point, why is there a sudden interest in bioengineering? Well, for one thing there are commercial applications; lots of people make money out of it. There is no prominent or even semi-prominent molecular biologist in the US and even, I believe, in Britain, who is not either the President or the Vice-President in some venture capital biotech company. Some of my colleagues are in it up to their necks, and they make a lot of money at it. That's one thing. Second, there is a different contradiction, which is a contradiction entirely within science and its relationship with the public, namely that scientists, in order to have their work supported, over and over again make promises, about how it's going to save lives or prolong lives and so on, and people are going to ask you to make good. And genetic engineering is yet a new way in which scientists hope to fulfil the promises scientists have made.

Take the wonders of modern medicine; modern biology has done virtually nothing to date about cancer. Cancer is being treated by the same method it has always been treated. You either cut it out, burn it out or poison it. And all our knowledge of cell biology has not changed that. We're told: "Give us a chance." But people after a while get tired of this. Medical biology since the second world war, 1946, has done precious little for my life expectancy. I am 68 years old, and when I looked most recently in the Statistical Abstracts in the US I discovered that my expected future years of life have increased (since 1947) by two years. So they're the wonders of modern biology. They haven't done much for my life expectancy, which is substantial, but it was substantial in 1947. What biologists keep doing is confusing two issues: one is the possibility of amelioration of one's condition, so that it is easier to get on. Or postponing death a little bit. They confuse that with preventing death. Biologists can't prevent death. They can only change its course. And they have changed it quite a lot. The agency of death has changed quite a lot. It used to be infectious disease in the 19th century and now it isn't any more. It's now heart disease, cancer and stroke and if genetic engineering should succeed in whipping cancer, in preventing heart disease and stroke, what then? We'll die of something else. So part of the big emphasis on bioengineering and biotechnology and genetic engineering has been to make good on promises they have not kept by saying "Well, we didn't understand how to do it before but now we've got the genes, when we've established the nexus, we will do the things we promised you". But they won't, because they can't. The machine knows how to die?

<u>Chairman:</u> I now call on Professor Birch to close the proceedings.

<u>Charles Birch:</u> I'm going to tell you a secret. I happened to be sitting with the group of examiners who were examining Richard Lewontin's PhD thesis in Columbia University. There was a lot of talking went on in that oral examination, mostly by the one person. Dick Lewontin's supervisor was Professor Dobzhansky, who turned to me and said: "You know, it's not a case of the examiners examining the candidate; the candidate is examining us."

Also while I was in Columbia University, the whole year happened to be the last year of Richard Lewontin's PhD, and we, together with a couple of other graduate students, used to go to lunch most days, to a drug store on the other side of Amsterdam Ave. One of the things we used to do was to try to introduce a word that the others didn't know. Dick turned up one day with the word `merkin'. None of us had heard of it and we had difficulty finding out what merkin was because it wasn't in the Concise Oxford Dictionary. I think it's in the American Chambers Dictionary. I'm not going to tell you

what merkin is but when I came to leave Columbia University, I was presented with a merkin by Dick Lewontin's colleagues.

The other thing I want to say is this. It's a little parable.
The US navy released the following report of an interaction from one of their ships:

Voice A: Please alter your course by 15 degrees South; you are on a collision course.
Voice B: You are on a collision course. Alter your course by 15 degrees North.
Voice A: You are mistaken. Please alter your course immediately . This is the Captain of a US warship.
Voice B: I don't care. You must alter your course.
Voice A: But this is the US aircraft carrier 'Enterprise'.
Voice B: And this is the Maidstone lighthouse.

This is a parable. In our midst, Richard Lewontin is a lighthouse. All those other biologists who don't see the light from the lighthouse are on a collision course. You can be on a collision course in all sorts of ways.

In my terms he is a prophet, and I think he was always a prophet. He certainly was when he was a graduate student. I remember on one occasion when he and I were having a discussion about something and his supervisor, Professor Dobzhansky, a very distinguished geneticist, poked his nose in the door and said "What are you two discussing?" and Dick replied "We're discussing philosophy; you wouldn't understand anything about that." Whereupon Professor Dobzhansky silently retreated.

Another thing I want to say is this. When he was talking I was thinking of a rather famous remark by H.L.Mencken: "To every human problem there is an answer that is simple, neat and wrong."

I was thinking : "How can we convert that??" To every human problem there is a answer that is (in Dick Lewontin's terms) complex, the possibility of lots of noise which is going to make things a lot more unclear, it has to be open ended so that it includes possibilities that we haven't thought of yet.

"To every human problem there is an answer which is..... and what is the answer?"

The final thing I want to say is: it's a tremendous pleasure for me to listen to Dick Lewontin because I have known him for more than 35 years. I met him first at Columbia; I used to meet him occasionally at Chicago before he moved to Harvard University, and then he spent over a year in the Zoology Department here in the University of Sydney. It is a honour and a privilege for us to have listened to him and to see that apart from being a great biologist he is such a tremendous exponent of his own field. Thank you very much Professor Lewontin.

Lewontin: Thank you Charles and CHAST and everyone who has made our visit so wonderful. And I really do appreciate your attention tonight.
