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The Scientist / Technologist Distinction
(or, who gets to play with toys?)

Introduction

It is currently fashionable in some circles to deny there is any difference between scientists and technologists. (For instance, in the area of "postmodern science studies"; amongst pragmatists, and indeed in the public at large (see Laidler 1998 for this later point.) However, I feel that this distinction is both epistemologically and ethically necessary. In the following paper I shall do three things in order to support the previous thesis. First I shall discuss the cognitive aims of both classes of disciplines to distinguish them. Second, I will show how these cognitive aims lead to different ethical considerations of each class. Third, I apply the previous categorizations for some difficult fields of activity, in specific that of computer scientist and of pharmaceutical chemist. This will suggest (as remarked by Bunge [1983, 1985]) that one ought to avoid the scientist/technologist dichotomy by placing an "applied scientist" category in between the two[1]. Each of the previous three sections will contain two parts, namely a substantive part and a response to those who would criticize it on various grounds.

Three warnings of note, before I begin, however. One is that translations of references in non-English language works are my own unless otherwise stated, and second, I presuppose both basic familiarity with philosophy, science and technology themselves. Third, I intend the focus to be the present day's science and technology, approximately. An appendix clairifies a point of ideosyncratic vocabulary of mine.

Section 1a - Cognitive Aims

In order to get at the cognitive aims of both scientists and technologists it is necessary to do two things: (a) examine what scientists say about the cognitive aims of science and its

[1] Note that Mitcham (1994) contains a mischaracterization of Bunge's current views (fully available to him in his *Treatise*) in an otherwise interesting and clever book. Mitcham claims that Bunge regards technology as applied science. (His conference paper of that title [referenced in Mitcham's book] was not chosen by him and misrepresents his views contained in it. Bunge 1998)

relation to ethics (b) to examine some of the methods used in both science and technology, because that will suggest one possible place where the ethics "fit in". First a note, however. I recognize that the same person can at different points in her career wear one "hat" rather than the other, or even in the course of one project or other wear two hats. This is often the case in computer science, as we shall see in section three.

(a)

Investigation of science's cognitive aims with an eye to ethics

I take it that basic scientists try to discover the way the world is. This can be the natural world, as in the case of physicists, chemists, geologists, biologists, etc. It can be the social world, as in the case of sociologists, historians, culturologists, economists, politologists[2] and so on. There are also scientists who study mixed systems, such as psychologists[3], anthropologists, (scientific) linguists[4], etc. This view point is supported by both textbooks and scientific journals, as well as by scientists themselves. An example follows. The following is from an interview with S. Gould in *Biology* (Campbell 1993) (emphasis added):

> "[...] The main point is that life is 3.5 billion years old and we got here yesterday speaking. Why should a process that's been going on that long in ignorance of us contain moral messages for our lives? It can't. **Science as an enterprise that deals with the factual state of the world, and you don't derive ethical beliefs from factual statements. The most science can do is supply information that may be relevant to ethical decisions, but it is never going to tell you what the proper behaviour is.** It just can't."

Gould's remark is explicit concerning what has been called the

[2] Note that I am using this instead of the more usual term, "political scientists" because many political scientists are closer to being political technologists or political philosophers.

[3] Also note that many psychologists on this "model of the division of intellectual labour" are both scientists and technologists, and as we shall see later, applied scientists as well.

[4] Some linguists study languages in themselves, and thus do not count as scientists on this categorization because they abstract from the world. Mathematicians are similar. Further, some linguists are much in what might be called the classical philology tradition, which is here regarded as a branch of the humanities with philosophy, religious studies (except as it overlaps into sociology, etc.), languages and literature.

ought/is distinction.

This view can be compressed into the following: because the world need not be the way it ought to be (for some humanly decided "ought") finding out about it cannot tell us this.

(b)

<u>Science & Technology's respective methods</u>

Technologists on the other hand are those who attempt to develop designs based on scientific results to modify the world or prevent modification in it. These include engineers, (science-oriented) managers, medical researchers (those that develop treatments at any rate), those who design psychotherapies, etc. Many disciplines that are currently uninformed by results of science may possibly become technologies, for example: law, (normative) international relations, normative economics, action theory etc.

Making use of Bunge's (1983) characterization of a scientific research field, we can sketch a brief account of what might be called a metamethod. Bunge's characterization involves representing a scientific research field as an ordered ten-tuple, a vector of the form ***R*** = <C,S,D,G,F,B,P,P,K,A,M>. He explains each component as follows (1983, pg. 202-203):

> "[...] where at any given moment: (i) the research community C has the same general characteristics as those of any other research field; (ii) the host society S of C has the same general characteristics of any other research field; (iii) the domain D of ***R*** is composed exclusively of (certified or putatively) real entities (rather than, say, freely floating ideas) past, present or future; (iv) the general outlook or philosophical background G of ***R*** includes (a) an ontology of changing things (rather than, say, one of ghostly or unchanging entities); (b) a realistic epistemology (instead of, say, an idealistic or conventionalist one), and (c) the ethos of the free search for truth, depth and system (rather than, say, the ethos of fatith or of the bound quest for utility, profit, power or consensus); (v) the formal background F of ***R*** is a colllection of up to date logical and matheamtical theories (rather than being empty or formed by obselete formal theories); (vi) the specific background B of ***R*** is a collection of up to date and reasonably well confirmed (yet corrigible) data, hypotheses and theories, and of reasonably effective research methods, obtained in otheer research fields relevant to ***R***; (vii) the problematics P of ***R*** consists exclusively of cognitive problems concerning the nature (in particular the laws) of the members of D, as well as

> problems concerning other components of ***R***; (viii) the fund of knowledge K of ***R*** is a collection of up to date and testable (though not final) theories, hypotheses, and data comptible with those in B, and obtained by members of C at previous times; (ix) the aims A of the members of C invluding discovering or using the laws of the D's, systematizing (into theories) hypotheses about D's, and refining methods in M; (x) the methodics M of ***R*** consist exclusively of scrutable (checkable, analyzable, criticizable) and justifiable (explainable) procedures, in the first place the scientific method; (xi) there is atleast one other contiguous scientific research field with the general characteristics noted with reference to research fields in general; (xii) the membership of everyone of the last eight components of ***R*** changes, however slowly at times, as a result of scientific research in the same field as well as in related fields of scientific enquiry."

From this we can extract the following basic characterization of a metamethod, known as the scientific method. (It is a metamethod because it is a description (a method) to fill in with specific methods.) The first important characteristic concerns background knowledge. No scientific hypothesis can be tested in isolation. The second is that what is being tested is both adequacy with the world and adequacy with what was previously known. Each scientific investigation has to balance these two criteria differently, however in each case the two components are not empty. Science thus makes use of both a coherentist and an a correspondantist epistemology. This is important for our purposes. Let us look at why.

Testing of scientific results and technological products is different because of the difference in cognitive aims of the two discipline families. Since a technology aims to change the world or prevent change (in one respect or other), the above method cannot be exclusively used. In spite of this difference, nevertheless technologists cannot (effectively by definition) ignore the scientific ways of finding out about the world. This suggests that technologists may make use of the general scientific (meta)method (discussed above), but in addition must use tests for efficiency, desirability, of the designs proposed. Technological investigation does not directly justify the science in which it is based, as very often important concerns such as safety factors mask theoretical calculation by orders of magntitude. On this consideration, the loss of concern for truth amongst technologists is made up by the importance of other factors.

These lead quickly into ethical considerations. One way to look at this is as the technological method (which is even more open ended than the scientific method) as scientific method plus a general theory of action. There are thus two ways in which technology leads to ethics. One is in how it proposes action (including inaction) and one way, parasitic on the first way, in which technological proposals may “embody” values in some sense. We shall meet these in section two, below, but first I should deal with possible objections to the account of cognitive differences explained above.

Section 1b - Response to Critics

For those who deny the scientist/technologist distinction and think I am begging the question, I have the following remarks. First, because the denier has to pick out all individuals in both classes as I have construed them and show that I am overlooking something, I move that the ball is now in her court. Second, as I hope to show below, some of the traditional ways in which the division is denied do not hold up, thus further shifting the burden of proof.

Thus I would like to put aside the issue of question begging, and move on to some more substantial objections. First would be from what Mitcham (1994) has called humanistic philosophies of technology. The most radical of these would be a hermeneutic attack on the scientist/technologist distinction, an approach owing much to the work of Heidegger.

To a strict hermeneuticist, all or that humans do is produce texts. Thus, Heidegger’s (1953) remark: “Im Wort, in der Sprache, werden und sind erst die Dinge” (Only in the word, in language, become and are things.) If that were true, then there would be no difference between science and technology; both would produce texts as primary or sole output. Since this is not the case, for at the very least a technologist often produces a blueprint or other plan, and a scientist produces a document that refers to something and not something with merely literary properties, this version of hermeneutics is false. *A fortiori*, any stronger version of hermeneutics (e.g. ontological hermeneutics, the thesis in which everything that exists is a text) is also false.

A slightly more sophisticated objection would come from a philosophical pragmatist. Dewey (1960 [1929]) defended a direct connection between science and praxis and hence technology, rather than a division along the lines I have outlined above. He claims that all science is technological in a broad sense because it involves action, particularly in experimentation.

Dewey's denial of the broad distinction has three roots. In my view, all three theses are false, and thus it bears investigating these as some may be tempted by one or more of these.

First is the banal point that scientific research involves action it thus should involve action that is responsible and focused towards securing human values such as security, and so on. The cognitive aim of science on this viewpoint would be instrumental. If taken in a weak way, Dewey's first thesis is merely that scientists should have values of a certain sort. This will be treated in the next section; the gist is that one has to distinguish two kinds of values and that science presupposes one kind and is not involved in the other. A stronger reading of the thesis, namely that scientists should pursue pure research that will lead to applications that can be sold (or are moral) or more generally, be used socially, rather than proceed in an disinterested manner, would cripple science. There are not many laws[5] of scientific research known but one appears to be that perhaps 1 in 10,000 or 100,000 scientific discoveries makes it into something socially useful, and further that which will make it is not generally knowable at the time of discovery. If this pattern is a law (and not merely a trend) purely "utilitarian" considerations would thus cripple scientific research.

A second, equally false root, of Dewey's pragmatism lies in an operationalist philosophy of science. Because operationalism "reduces" properties to how they are measured, one does not really

[5] I use "law" after Bunge (1979) to mean objective regularity in nature or society. Law_2 means our reconstruction of these patterns (as in, e.g., Newton's Laws).

discover properties about the world at all, and science (through experimentation) becomes, in Dewey's words, a means of control, technology. Now is not the time to rehearse the problems with operationalism (for which, see Bunge 1998). However, it bears noting that Dewey's operationalism does not extend to phenomenal properties. Since adopting an operationalist stance to the qualities (supposedly) discovered by physics allows one (according to Dewey, and Eddington, the physicist he draws upon) to take an anti-realist stance towards them in order to "sozein ta phainomena", if one were to do the same (as one would have to in a Deweyian psychology) towards phenomenal properties one would have to presumably take an anti-realist stance to them as well. This is clearly undesirable under Dewey's view, but seems to point to an inconsistency, or at least a break in the <u>sciences</u> that one cannot easily account for.

The final, and in my view, most pernicious, origin of Dewey's views in this area concerns subjectivist misinterpretations of both special relativity and quantum mechanics. Dewey claims that in order that both these intellectual revolutions were able to take place, what he calls the old conception of science where the observer (scientist) had no influence on what was discovered must have been jettisoned. Hence, all scientific investigation was also a matter of control/technology because all investigation must proceed under this "influence model." Unfortunately, this is outrageously false. (See Stenger 1995; Bunge, ed. 1967 for the quantum mechanics case. The latter even includes several <u>disproofs</u> of this mistaken view.) As for the case of special relativity, it is important to note that Dewey makes use of a popularization, and makes the same error Latour (1988) was to make much later. This mistake involves thinking that the humans involved diadictally in Einstein's popularization are actually part of the genuine apparatus of the theory.

Thus we have dealt with Deweyian objections to the cognitive aim of science. I have dealt with Dewey's account in some detail as his mistakes are very common, so dealing with them in this detail allows a whole family of possible objections to my account at once.

I briefly mentioned Latour in passing in the previous passage. Since Latour is one representative of a greater movement which (in my view) totally distorts the cognitive aims of science and technology, and is very influential, I will spend some time discussing what I will label “postmodernist” accounts of science[6].

The postmodernist viewpoint can be construed as one denying that the world plays little or not role in what becomes scientific knowledge. This is supported by various arguments of varying plausibility. Some (e.g. Feyerabend 1975) suggest that this comes out of a consideration of scientific method. He suggests that because all methods have limitations and weaknesses and such ‘anything goes’. Thus since science isn’t anything “special” at all, it is thus not distinct from technology. The blatant non-sequitur in Feyerabend’s argument has been pointed out repeatedly (e.g. Haack 1998), and yet is very common in postmodern discussions of scientific method.

I suggest that this is one of the main origins of “postmodern” accounts of science, which can be summed up in the slogan “nothing but-ism.” This slogan indicates that those who hold this account of science latch onto one feature (often one feature of a small number of specific scientific investigation) and claim that it applies as an “omniexplanation”. One example: Evelyn Fox-Keller makes such a move in her recent (1995) book. Therein she investigates Schrödinger’s popularization of biology, *What is Life?* She suggests personal motivations for Schrödinger’s investigations into life and the second law of thermodynamics, claiming his concern was not merely scientific curiousity, but a deep personal quest of dealing with stability (she brings in the social circumstances surrounding the situation Schrödinger was in - exile from Nazi Germany, etc.). Nowhere does she deal with the

[6] These views are varied in many different respects and lumping many thinkers under the same label may be regareded as unfair. However, the general features of the thinkers I will be referring to are sufficiently close in scope that my general comments will apply to all. After all, the criticism applies to those who adopt the viewpoints criticized - the label we attribute to those who hold such viewpoints is not terribly important. For more detailed criticism along the lines I am making see, e.g., Gross and Levitt 1994, Koertege (ed.) 1998, Sokal and Bricmont 1998.

possible evidence against her interpretation. This latter issue is very pertinent to a study of the scientist/technologist distinction because the feature of this investigation concerns interests. Schrödinger is given a technologicist-like (in the account above) goal for basic science - stability. Thus, it could be claimed, if Fox-Keller is right, that motivations are common to scientists and technologists - they both want control of something, and hence the supposed demarcation is a delusion. This point is explicitly made in other "feminist critiques" of science, notably those of Sandra Harding (1986)[7].

But the above is a notoriously bad argument. Cognitive aims are cognitive aims, regardless of motivation for them. So even if Fox-Keller and Harding are correct about "unexamined motivations" behind any or all scientific research, it simply does not follow that the stated aims are "untrue" or misleading. This can also be put as "look at what the scientists or technologists do, rather than what they say."

A similar but slightly more moderate version of this situation can be seen in the writings of Gieryn (1999). Gieryn claims that because the cognitive[8] boundaries of what counts as science are changing entail that science has no fixed core. Gieryn studies several episodes in the history of science to marshall his conclusion. However, he merely presents the cases and never directly supports his thesis. In order to show that science has no fixed core of cognitive aims (as is the contention of the present paper) it is not sufficient to show that what counts as science varies and in an ad hoc way. For instance, because Gieryn makes heavy use of certain thinkers emphasizing a rationalistic component to the epistemology and others emphasizing an empiricist component. What would need to be shown is that what counts has nothing in common with each other, and further, that these understandings of science are mainstream (and are not [lunatic]

[7] Harding's stronger claims, namely that science and technology are identical because they both attempt to "control women" or something along those lines, are blatantly false and need not be dealt with here. (See Gross and Levitt 1994 for criticism.)

[8] Gieryn also considers other non-cogntive boundaries, but for the present purposes that is all that is necessary to remark on.

fringe amongst scientists[9]). For instance, cannot rationalism and empiricism be complementary (in the right way), as I have suggested above? Gieryn notes that (e.g.) Tyndall remarked that science was rationalistic to the engineers, to contrast it with their occupation and that it was empiricist to the clergy to compare science with religion. Gieryn hints that this is an example of science being “relabeled” based on interest. Well, to some extend that is true, but one would have to show that the other aspects that Tyndall did not emphasize to a given audience were regarded as nonexistent, or not part of science. Gieryn does not do this, and so the strongest reading of his “shifting boundaries” thesis does not hold water.

Were it argued that my labeling something “scientific mainstream” I am begging the question against some sort of contextualism, the response is simply that I believe those who deny the tree structure of science I have presented in the previous section have the burden of proof now that I have sketched my positive account.

Another objection that might be raised against this account governs important inventions that were not developed in light of the science of the day: printing press; steam engine; spinning jenny; pendulum clock. By saying that science is cognitively prior to technology, how does one account for these monumental inventions? This criticism is inappropriate, in the light of what has already been said, but it is bound to occur to someone anyway, especially if it is conflated with the next objection. The answer to this one is simply to pay attention to the time period under discussion again. As remarked above, this paper concerns itself with the 20th century and the early 21st. At this point, it appears that all future great inventions will be science based, hence the adoption of the definition of technology that excludes

[9] For instance, he discusses with admirable detail the population at large’s treatment of phrenology. But this merely shows that pseudoscience can apparently be more “democratic” than genuine science. Genuine science is elitist in so far as scientists ought to pursue their own scientific interests and not those of the public at large. This is both because one cannot predict what basic findings are going to prove useful and because restricting basic research can be seen as culturally impoverishing in much the same way that restricting genuine art would be.

what Laidler (1998) calls “empirical inventions”.

A related objection to the previous one concerns “high technology” used in research. Some point out that (e.g.) particle physics requires expensive, advanced technology devices. Hence technology procedes science, for without the advanced devices, there would be no particle physics. This objection (while common) actually betrays ignorance of the science involved in these cases. Instruments are designed with the principles of the science in question, and have often little use outside the basic science (or in some cases applied science - see later) in which they are used.

Section 2a - Ethics

It has been claimed that one possibility for the distinction between science and technology lies in science being ethically neutral. This thesis is ambiguous. Here I distinguish what might be called endoethics and exoethics. Endoethics is not found in science, which is to say that the results of science (partially true systems of propositions about the world) do not have ethical content. Exoethics is the ethics used by (e.g.) scientists in order to achieve the aforementioned cognitive goal, discussed heavily in the previous two subsections of the paper. These norms are those that (e.g.) Merton (1973) has identified in the case of scientists. Another set of norms applies to technologists, which we shall see in due course.

Merton’s norms are as follows: intellectual honesty, integreity, humility, disinterestedness, organized skepticism, universalism, impersonality and communism of intellectual property. Humility here should be interpreted somewhat epistemologically - scientists ought to revise their views of the world based on good evidence and so forth. It may strike some as odd that the Mertonian norms are ethical norms, rather than say, merely practical ones. But ethical norms they are, for they proscribe actions as being wrong in a given context. One does not have to hold a view inspired by a “divine command” conception of ethics to see this. Even an extremem utilitarian can look at the historical record and see that if Merton’s norms are violated (e.g. the Lysenko scandal in the Soviet Union) bad results happen. This latter case is also an example of confusing science and technology.

Science is thus not completely morally neutral; nor we do we want it to be. (Arguably, it would not function as well as it does without this exomorality. See Wray 2000.) Its results are morally neutral.

But why is science ethically neutral in the endomorality sense? In short, because it is impossible to derive any statements about action from nomological ones without deriving their dual. Let us take Galileo's law of falling bodies as a case study. This can be stated in modern terms as: $\frac{d^2 s}{dt^2} = g$, where g is a constant assuming the falling body is relatively free of air resistance and the height from which the object fell is small compared to the radius of the earth; s is the distance fallen. To draw any moral conclusion from this cognitive result, we must first supplant it with a moral principle. At least two broad classes of principles can apply, one suggesting that (in a given case) falling bodies are "a good thing", and another that they are "a bad thing". Simply: the statement of Galileo's law does not allow us to conclude that either (or both, or neither) is of these desirable. It entails neither. This can be rigorously defended with a theory of reference and similar tools, but I shall not do that here, in the interests of avoiding too many technical details.

Contrapositively, because products of technological research are plans for action, they can be moral or immoral[10]. How this is exactly to be spelled out is subject to some debate. One possible approach would be to use a set of norms, parallel to the Mertonian ones for scientists. One such norm could be "Your invention shall assist someone meet basic needs or legitimate desires" (paraphrased from Bunge 1996). I move that this is a good start for an ethics of technology, but is insufficiently precise to serve. The first clause of this is understandable, though is insufficient because clearly some nonmoral factors interface with this ethical one, such as efficiency. However, without an account of "legitimate desires", the norm is woefully underdeveloped.

[10] I am using "moral" and "ethical" interchangeably, with "ethics" being the study of morality, both descriptive and prescriptive.

(Bunge’s own suggestion, that legitimite desires are those which do not interfere with the ability of others to fulfill their basic needs suffers from the imprecision of “interfere”.

One possibility is that attention should be paid to the biases embodied in a technological proposal (Friedman & Nissenbaum 1997). My adaptation of their schema to technology in general from their account of one for computing technologies allows us another axis by which compare science and technology.

These three kinds of bias are: preexisting, technical, and emergent. Preexisting bias arises from roots in societal incitations, practices and attitudes that preexist the technology. Technical biases occur due to limitation of technical tools. For instance, when something continuous is discretized for ease of calculation or implementation. Emergent biases are the most difficult to discover, as we shall see, as they arise when a technology is put to a slightly different use than was intended. (Note that this can result from changes in the social environment in which the artifacts designed in light of the technology exist.)

If we investigate scientific results for bias we see that it is simply not the kind of things that can result from scientific research, by the definition of science we have sketched above. To equivocate slightly to make the point: biased science is, in essence, not science, as it does not attempt to faithfully understand the way the world is.

We have seen above that testing of scientific results and technological products is different and that this stems from different cognitive aims. Let us now see how this difference in testing leads to differences in the ethics of science (and of scientists) vs. the ethics of technologists and technology.

In our consideration of bias, three kinds were noted, whose nature transformed into the following suggested norms for technologists:

(a) Be aware of preexisting bias, and try and avoid it in design.
(b) Be prepared to rework designs as awareness of bias comes to light.

(c) Document technical biases as far as possible at least far one’s own notes are concerned; that way if a difficulty with (say) an approximation arises, it can be put in context more easily.
(d) Be aware that emergent biases are virtually inevitable, and be prepared to redesign to overcome them.

Of course, these responsibilities support and suggest several ethical rights of the technologist.

(e) Some degree of preexisting bias is inevitable in all design, and technologists have the right to defense against charges of preexisting bias
(f) Technologists have the right to redesgin as awareness of preexisting or emergent bias comes to light
(g) Some technologists should periodically oversee the work of others so that (in particular, but not limited to) technical bias can scrutinized
(h) Technologists have the right to set limits of applicability of their designs and to “disown” use beyond a certain limit.

But of course biases are not the only ethical issue one ought to be concerned with in technology. Another possible area is hinted at in point (h) above. This concerns limits of use. Examples of this abound: “Keep out of reach of children.”; “Not safe for children under 6.”; “Do not take with drug xyz.”; “Do not draw more than 100 mA from this port.”; “For external use only.” and so on. Compare this with the results of scientific investigation: how does one set a limit to use of “the hydrogen atom has a single proton”; “all vertebrates have a notochord at some point during their development”; “revolutions occur slightly after oppressing power begins to wane”[11]. The only possible restriction on these conceivably could be “do not use them for evil”. But this is not a helpful thing to say for several reasons. One, no result from (basic) science can lead directly to technological applications (try it with the above statements!), as already remarked. Second, “evil” (at least on many accounts of morality) is contextual -

[11] I note in passing that this seems to be one of the few genuine laws$_2$ of history. (This conceivably makes possible some sort of historical technology!)

only on very strictly nonconsequentialist accounts[12] is it not. Third, one could just as easily say “use them for good!” with as much justification.

Another sort of ethics of technology issue concerns disclosure of flaws. This is a difficult and troublesome area. Science, as we have seen, normally concerns itself with partial truths. Technology has to make use of these, and often further approximations. For instance, we know that Newtonian mechanics is not quite correct, and we even have slightly more accurate theories under certain circumstances. But yet we can develop technology (even as sophisticated as plans for moon rockets) whose scientific roots are based on it. The question is the <u>moral</u> status of such approximations, and other known oversights. This is connected strongly to the issues of technical bias, discussed above. In particular, how are <u>technologists</u> responsible for this. Again, the solution seems to be documentation of approximations, use of “safety factors”, and disclaimers telling of inapplicable use. But what counts as such things to report is often hairy. Does a computer program that fails to produce a correct answer to a calculation one time in one billion runs count as buggy?

Clearly context is important, and then matters become difficult. To a user interested in calculating taxes, the notorious Pentium bug was likely to be largely unimportant. But if the extra precision was needed to calculate a dose of radiation or a concentration of drug to administer, then a tiny bug could very well have proved fatal (cf. Leveson & Turner 1993). This is why I suggest full disclosure, particularly when technologies are embedded in one another. Notice that this the defining characteristic of the latter sort of case. Computer technologies are embedded in a medical technology, and so the interaction is what is critical. Does this mean open source software is morally required? Or open source to those who would embody the software in a larger artifact than “merely” a computing system. Does the construction of a computer controled x-ray machine require that the ROMs on the motherboard of the conventional computer involved have their source available for scrutiny?

[12] The perennial favourite amongst philosophers to at least talk about in this regard is that of Kant.

The present author does not know at this stage. It is possible that adequate disclaimers in a particular context may override the obligation to document. Of this more in the next section.

Another proposed solution to dangerous use that comes saliently out in light of the science/technology distinction. This concerns what might be called self-limiting technologies. Danielson (2000) has proposed that devices should attempt to weed out more dangerous uses - for example, a car with an intelligence test to prevent children and drunks from using it. This clearly has a role to play in technologies which do not themselves embody (e.g.) destructive or preexisting bias. But this proposal does not work as easily with sociotechnologies, nor does it help to us to determine if there are any technologies which necessarily embody wrong morals (whatever these may be - offensive weapons, for instance).

It does allow us to make another moral distinction between science and technology, however. Scientific results not only do not embody values, they are simply not the sort of thing that can, and the above proposal is another way of showing why. A scientific result is a law statement, or a system of law statements (i.e. a theory), and not a <u>rule</u>. The logical form of rules and law statements is different; it is thus not surprising that they are not the same.

A final normative dimension we shall analyze in this paper concerns simplicity. Often simplicity is disvaluable in science; the world is complicated and it is thus not surprising that a more complex hypothesis is more correct than a simple one. On the other hand, simplicism in technology is much more ambivalent. A consumer technology if it is to be successful is more likely to require simplicity than a vertical market technology. On the other hand, in a vertical market there are often more directly ethical factors at work; perhaps the technology is being used for a more directly life, environment or property impacting use. Simplicity allows less qualifications needed for a technology’s use, which means a value of equality of opportunity is supported. On the other hand, a simple technological plan may not be as effective in meeting a goal. Simplicity is thus only <u>one</u> virtue.

Section 2b - Response to Criticism

It may be rejoined that some knowledge is inherently dangerous, or so overwhelmingly “saturated” with bad outcomes. Bill Joy (2000) has argued this in a recent issue of *Wired.* He claims knowledge of robotics, nanotechnology and genetic engineering are so dangerous that we should think twice before developing these. He waffles (as we shall see) on whether he is regarding this as a critique of science or of technology as the following passages indicate. I will take it that he is referring to both the basic science involved in these cases and the technology. (As we shall see below in section three, he may be also said to be indicting the “applied science” as well as the basic science.)

> “The only realistic alternative I see is relinquishment: to limit development of the technologies that are too dangerous, by limiting our pursuit of certain kinds of **knowledge**.
>
> Yes, I know, knowledge is good, as is the search for new truths. We have been seeking knowledge since ancient times. Aristotle opened his Metaphysics with the simple statement: “All men by nature desire to know.” We have, as a bedrock value in our society, long agreed on the value of open access to information, and recognize the problems that arise with attempts to restrict access to and development of knowledge. In recent times we have come to revere scientific knowledge. “ (Joy 2000, pg. 8, bold added)

and later:

> “It was Nietzsche who warned us, at the end of the 19th century, not only that God is dead but that “Faith in science, which after all exists undeniably, cannot owe its origin o a calculus of utility; it must have originated *in spite of* the fact that the disutility and dangerousness of the ‘will to truth,’ of ‘truth at any price’ is proved to it constantly. It is this further danger that we now fully face - the consequences of our truth seeking. The truth that **science** seeks can certainly be considered a dangerous substitute for God if it is likely to lead to our extinction.“ (Joy 2000, pg. 9, bold added)

It is trivially true that a technologist produces new knowledge in terms of “knowledge of how to put something together.” But this does not seem to be Joy’s intention. He seems to think that by simply trying to know, we are doing something wrong because trying to know leads us to compare ourselves with God. This sounds dangerously like the Lucifer sin in traditional Christian theology. But that is not in itself a terribly persuasive argument, especially if one considers at the cultural benefits that result from the 'will to know'. What really is the danger? In fact, the very thinker Joy quotes in the second quotation, Nietzsche, provides us with an answer - "will to power." Power must be tempered with ethics. Knowledge (Bacon not withstanding) by itself is not power.

It is also important to realize that the account of (basic) science above does not commit one to thinking that science is godlike. Science does not discover all truths of relevance to human life. (It does, however, seem to have the best way known of checking and systemizating them.)

Joy's complaints seem to center around how certain kinds of knowledge, by simply being made available will be used for evil. Well, if they not made available, how can they be used for good? As I noted above, results in basic science can be used for good as well as evil. (And very often, it must be noted, for neither, as their applicability is nonexistent.) One can interpret his remarks as a plea for moral education and responsibility taking amongst technologists and societies at large. This I think we should consider.

We shall see that a good way to further answer his worries can be answered by postulating a third category of persons in this general area, the applied scientist. See below in section three for this.

Another objection comes from environmentalists and animal rights activists (of certain kinds). This objection would be phrased as follows "Scientists pillage the environment and torture animals to discover the way the world works. I think this is the sort of knowledge that should be forbidden. We need not know what cats see or how monkeys react to stress."[13] There are several ways in which this concern can be spelled out, and depending on how, the

[13] I am indebted to Marjorie Caruso, a close friend of mine, for comments and suggestions along these lines.

response that should be made is different. The first concerns <u>how</u> animals and the environment generally are used. Questions of efficiency <u>of an investigation</u> are relevant to scientific research - it is important that it not be <u>wasteful</u>.

Second, more critically, is investigation <u>of</u> (nonhuman) animals wrong? Some would suggest that it is okay to use human subjects in experiments because they can consent to the procedures in question, and hence it is wrong to use non-humans because they cannot give consent. In the cat vision case (see Whitehouse 1999), a cat cannot say that it does or does not wish to be attached to a (somewhat invasive) neuronal monitoring device. A similar question can be raised about investigating the environment generally. Problems with rejecting this realm of “things to know” is deciding where to draw the line. Most individuals would have no problem with scientists putting paramecia under microscopes or investigating petals that fell off flowers. It is when investigation turns to animals or large plants that people have raised objections. But there is no good way to draw lines in biology. There is no “hierarchy” of life that one can appeal to directly. Even more curiously, we cannot directly find out about such matters (as intuitions on these issues is notoriously fallible) and thus must rely somewhat on scientific investigation to give us information about putative “hands off” areas.

The third nuance of the above question concerns the use of (for instance) animals in medical or pharmaceutical research, where the animal’s systems are stand ins for human systems of some kind. Again one has to decide at what point other animals are sufficiently humanlike that subjecting them to disease, etc. is wrong. A possible solution to this is to consider that animals raised specifically for lab purposes would not otherwise have lived and so (possibly) their life is less valuable. This answer will not be satisfactory to many, as they regard the creation of (certain) life that will ultimately be destroyed for our ends to be morally objectionable. The present author cannot adjudicate this vexing dilemma at this time, though feels that since humans are (under most ethical systems) by definition under consideration. I default to supporting <u>only</u> ethical consideration for humans, and so do so in this case.

But this latter case is the most interesting for our present discussion, because it leads directly into questions of applied science and technology. See below, but first a brief summary of what this section has accomplished.

As noted above, there are at least three possible “axises” on which responsibility for flaws and approximations in technology can be adjudicated. Each technology, or perhaps family of technologies (assuming family is not taken too broadly) should be evaluated on its own merits. This does not entail that we cannot evaluate technology in the light of others. It merely rules out “Oh, X is too much like Y! Deal with X!” as being relevant without argument.
Another possible objection concerns users. I have focused on how the technology itself is to be designed and what sorts of things technologists should be aware of when designing. Someone may rejoin that technologists may propose anything they wish, and leave it up to people generally whether they wish to use the plans proposed.

This objection has two readings, a weak and a strong one. On the weak reading, I am in perfect agreement. This seems to be the thesis that technologists should consult with the public in a democratic and responsible manner. (This would presuppose some degree of what might be called “technoliteracy” on the part of the citizens, however, and, more importantly, some resistance to the persuasasions of demagogues and charlatans. This quickly gets us into issues in the philosophy of education. I recognize there is thus a strong tie between the philosophy of education and the social and political philosophy of technology, but I shall not discuss this further in the interests that the present paper be manageable.) But on the strong reading, that technologists be leave everything up to the public strikes me as dangerous, because only technologists (note: it need not be the technologists proposing X that get to do all the speaking about X to the public; here is a reason for an independant technology review board.) may be as competant to grasp the possible impacts of technology. Of course, as we have seen above, we cannot abandon the populous either, as they should be able to explain their concerns - either directly, or through advocates of some kind. (This is sounding very legalistic. Granted, but note that under the conception of law as a sociotechnology and sociotechnic, there is an interesting self-referential loop involved.)

Section 3a- Categorization and Development of "Applied Science"

As has been remarked in the introduction, several fields of activity present themselves as being particularly problematic.

I shall begin by examining "computer science" as a paradigmatic case of a problematic field. As we have see above, the cognitive aims of science include finding maximally true accounts about the world with the means of experiment, etc.

Note that one cannot simply appeal to the artifactual status of the objects of study to assert that computer scientists are technologists. This move cannot be made for it would make mathematicians technologists. Mathematical objects are also[14] purely objects of our creation too, but since they are (or rather, we pretend they are) not concrete they do not fit in our implicit definition of technology above. A similar argument goes for social scientists. Society and its subsystems are largely artifactual, but that does not mean their study is hence technological. In fact, by the definition of science above, this cannot be the case. In fact, as we have seen, there are even social technologies. It seems that the applied science/technology and basic science/applied sciences distinction I will sketch below are more difficult to see in the case of social areas.

But what of these "trouble cases"? Let us investigate computer science (hereafter, CS). Consider the case of a professor of CS who develops a new programming language. Are they doing basic research, trying to find a new way of looking at (say) computation? Or are they proposing a new technology that could

[14] I am assuming a non-realist mathematical ontology in order to phrase this objection. Of course, if one happens to be a realist, then clearly mathematics is not a technology under most conceptions of mathematical realism. (Elaborating on this point seems useless as I am not aware of any mathematical realist who also insists this view destroys the science/technology distinction.)

perhaps be used by industry or government to sell, publicly implement, etc.?

I would argue that the CS professor is moving away from basic research into an area that is not foreseen to result in plans for artifacts. The language may be eventually involved in doing so, though almost never in the form as developed.

A similar case occurs in pharmaceutical research. Certain chemists work in developing understanding of compounds shown to have some pharmacological effect. They explore chemically similar species to see which ones can be made with similar effects as the initial compound. They also investigate ways in which different catalysts and reaction conditions can aid synthesis of these compounds and conditions of scaling. Yet they are not responsible directly for developing a drug from these products. Again we have a case of "middle ground."

I argue that based on considerations from these two above cases we have reason to employ a third label in addition to "scientist" and "technologist". For lack of a better term, I suggest "applied scientist", and move that we label what was previously called "scientist" in turn "basic scientist."

Section 3b - Ethics and the Applied Scientist

What can we say about the ethics of the applied scientist? If her cognitive aims are "between" in some sense the basic scientist and the technologist, the above framework suggests that we place her ethical responsibilities between the two as well.

Because applied scientists are much closer to plans for action than basic scientists, they can begin the ethical evaluation of what is possibly an outcome. This can occur as part of their duties to the technologist generally. "If you take this route, you will be in danger here." For instance a recommendation could go as follows: "This algorithm works okay in main memory, but is too inefficient for secondary storage, and so if timing is crucial in your application, remember that $O(n^3)$ running time with 1 megabyte blocks is going to be very slow indeed."

Here is another example from the pharmaceutical applied sciences. "This reaction works at scales x through y, but above y impurity z becomes significant (s parts per million) to human consumers, so this reaction is unusable at scales thus and so." The applied scientist thus has to accomodate both possible moralities - she is must be both aware of action and of the desire to know.

Note that because one person may "wear at different times different hats" a focus of ethical evaluations of technologists might revolve when they were acting qua technologist and when they were doing other things. This is very often the case in computer science, particularly in database design and file systems work. Let us look at some cases here in order to draw some moral lessons.

The same individual may work on research into efficient file systems and mechanisms of database design as who actually goes about and develops the schema for a database or information system proper (cf. Merrett 1984, which discusses both issues).

It is also important ethically (and cognitively, to some extent) that one can be <u>mistaken</u> about one's own characterization. This is particularly important in the case of a discipline like robotics or biotechnology. As we have seen above, Bill Joy is concerned with these fields. Remarks here may help to further alleviate his worries. The applied science of robotics (for instance, that of the Cog project at MIT: see Dennett 1998 (1994)) attempts to discover ways by which (e.g.) vision can be implemented using conventional robotics. The Cog team should be aware that these investigations can make no technological recommendation directly. The <u>goal</u> of the technological proposal is missing. Of course, Cog's researchers, once "done" with their applied science, may change hats and enter the technological sphere. Note that at what point exactly this occurs, as with the exact point where basic science becomes applied, is somewhat ill specified. This is important to the issue of mistakes, as not only can researchers be mistaken about what they are doing (as some have claimed, e.g. Hans Moravec is) but technological review committees, etc. can be as well. But there <u>is</u> a clearcut distinction between basic science and technology, as we have seen. The "middle ground" is the hardest to map out, especially ethically, as we have seen.

Section 4 - Conclusion

We have seen that in order to better understand the ethics of the scientist and the technologist we must investigate the cognitive aims of both disciplines. The dichotomy of the initial characterization seemed too crude to clearly answer this, and so we developed the concept of the applied scientist. Each group has their own relation to cognitive goals and to praxis, and thus their own ethics. The ethics of the basic scientist is strictly externalistic - it concerns itself with how the science gets done, rather than its content. The ethics of the applied scientist is similar, but in addition she must be aware of practical concerns of her work, which lead to some ethical considerations. Finally, the technologist's proposing plans for action immediately raise questions of right action, motive and various other morally relevant categories.

Appendix 1 - Technologist / Technician

It may be objected that I am using technologist in an unusual fashion. Granted; the goal of this appendix is to suggest a distinction between technologists and technicians which ought to be made to understand some possible objections to the account I have sketched elsewhere in the paper.

Technicians are those who use the result of the technology in action. Computer assemblers, auto manufacturers and mechanics, and even lawyers (hopefully) and physicians (when treating patients) become technicians on this account. I use the terminology this way so that performers of each kind of activity have their own label. This "ontological carving" allows greater freedom in moral evaluation, as has been noted.

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