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Ethics and science: a time for precaution

The situation of science and scientists today is neither clear nor simple. On some very important issues, such as GMOs, climate change and nanotechnology, there are some intense controversies brewing; even power struggles that border on violence. In short, science and scientists now find themselves in the eye of the storm. The question of ethics has become more important than ever. What is the place of ethics in today's scientific world?

I would like to present the focus of my work and a hypothesis. My thoughts belong to a genre that can be defined as 'applied ethics'. This is a theoretical reflection with a clear aim to provide a solution to a problem facing society today. I also state a hypothesis that scientific ethics are built around cardinal values, with the central ideas having been, throughout history, truth, utility and progress.

The central theme of my argument is to show that with advances in technosciences and the ever increasing power of the market, we have 'changed worlds' and that we are now living in a world that I would label as 'a fragile, complex and uncertain world'. Therefore a new cardinal value is required; one that I call precaution. It is my view that it should replace the ideology of progress, and lay out a new method of growth, in particular a new relationship with nature, a new rationality, a new understanding of action.

It is in this context alone that the principle of precaution may be understood for what it is: a profoundly innovative principle, for which I will illustrate the ethical dimensions. I will develop my work in three parts. First Science and Ethics - Past and Present, then Entering the World of Precaution and finally the Precautionary Principle - an Ethical Principle.

Part I: the link between science and ethics, of past and present

I will break this down into three sub-sections: science and its values, a historical approach. Shaky foundations. What stage are we at?

And so to start with, the historical approach articulated around these three cardinal values of science that are truth, utility and progress.

Science first appears closely related to the value of 'truth'. This seems true by just looking at its methodology; questioning. Science (but also philosophy, as in the beginning there was no difference between them) starts with wonderment and the desire to understand, to find the truth beyond appearances. This requires a certain distancing and examination from initial insights and/or common opinion. Questioning as a method substitutes reason in the legendary, "*Wonderment; philosophy has no other origin*" (Plato, *Theaetetus*, 155D). "*It was wonderment that leads the first thinkers to philosophical speculation.*" (Aristotle, *Metaphysics*, 982 b13). (Vernant, *Myth and Thought among the Greeks*).

Aristotle made a symbolic gesture that illustrates better than anything else this quest for knowledge and truth, and his "parricide" against his master Plato, "Yet it would perhaps be thought to be better, indeed to be our duty, for the sake of maintaining the truth even to destroy what touches us closely, especially as we are philosophers; for, while both are dear, piety requires us to honour truth above our friends" (E.N. I, 4).

Sometimes the knowledge gained by philosophers and scientists can be troublesome, contradicting previously accepted truths, particularly if they have religious or political implications. The trial of

Galileo in 1633 is emblematic. Another example would be the attacks against Darwin and Darwinism, which haven't ceased since the publication of the *Origin of the Species* in 1859, with the persistence of a strong 'creationist' opposition, one that is particularly rife in the USA. Going against a dominant opinion, or against the interests of a dominant group requires courage, such as the current and often precarious position of those known as 'whistleblowers'. Associated with truth, courage is a value of science and scientists.

A new cardinal value has, however, quite quickly emerged to compete with truth: utility. Descartes already predicted it, "But as soon as I had acquired some general notions respecting physics [...], I observed how far they can carry us [...] I believed that I could not keep them concealed [...]. For by them I perceived it to be possible to arrive at knowledge highly useful in life, and in room of the speculative philosophy usually taught in the schools, to discover a practical [...] and thus render ourselves the lords and possessors of nature". It is spectacular to see how Francis Bacon (*New Atlantis*, 1626) foresaw the necessary consequence of advances in knowledge: the increasing power of man over nature. He writes of this utopia, one that has largely become a reality today, "And many of them [plants] we so order, as they become of medicinal use. We also have means to make divers plants rise by a mixture of earths without seeds".

But it is of course utilitarianism that would consider all the consequences (ethical ones in particular) of this new attitude. With utilitarianism, what becomes central for ethics is utility, understood as maximizing the sum total of pleasures. Attention is then completely focused on the consequences of the action, and the question of a theory's 'truth' becomes secondary. "Nature has placed mankind under the governance of two sovereign masters, pain and pleasure. It is for them alone to point out what we ought to do", wrote Bentham, (*The Principles of Morals and Legislation*, 1789). Here it clearly appears that it is not the truth that should be our guide.

Positivism considered all the consequences of this position. First, in the scientific domain, "Descartes, with his vortices, his hooked atoms, and the like, explained everything and calculated nothing; Newton, with the inverse square law of gravitation, calculated everything and explained nothing. History has endorsed Newton [...] *Hypothesis non fingo*: At the end of the 17th Century they had come to declare that after all there was no reason to seek an explanation when you had a formula which worked well", wrote R. Thom (*Structural Stability and Morphogenesis*).

A. Comte would make this process systematic for all knowledge and thought, by defining a philosophical positivism; that which is positive is 'real, useful, certain, precise' - but there is no mention of truth. And yet it's the question of truth that can be found 'degraded', and even avoided, side-stepped because it wastes time, energy and everything would be in vain as it holds no solution. It means forgetting about metaphysical issues, "The human mind has already abandoned its absolute searches which were appropriate only in its infancy and is limiting its efforts in the rapidly progressing field of true observation, the only possible basis for truly accessible knowledge, sagely adapted to suit our actual needs", wrote Comte (*Course of Positive Philosophy*, 1830 – 1842).

A significant change will occur with the passing, in what should be the goal of our actions, from utility to preference. This shift is not without consequence. If utility still bears reference to a 'common world', with the theory of preferences, this world itself disappears from the horizon of reflection (Pareto who theorises the passing from the 'cardinal theory' to the 'ordinal theory' of utility in his *Course of Political Economy* (1897)). We can no longer think about what would be, in general, useful for one person; there is no longer any room for individual preferences (we could say, "that which is useful, is that which I prefer").

This shift from truth to utility can be observed with Pasteur. His work, in particular, focused on 'microbes'; specifically the question of their origin - could they form through spontaneous generation? - and sterilisation processes. This work caught the interest of the hygienist movement to the highest degree. This movement would work to restore France with an energy whose absence had

contributed to the defeat of 1870. Pasteur was convinced of the truth in his position, but the experiments that he gave as justification of his thesis were few, and one of them seemed to contradict it. His scientific opponents criticised him for generalising his results too soon, and Pasteur disguised the results of his unfavourable experiments. At the same time the hygienist movement unwaveringly supported Pasteur over his opponents, who had good reasons to reject them... but they were unable to make themselves heard. In this case, utility won out over the search for truth, even if, as subsequent events showed, Pasteur was right in his central theory against his detractors.

A new transformation would still upset the balance between science and its values. The ideology of progress would soon sweep up everything. Progress first appeared as a regulatory idea, in the Kantian sense. An idea, in this sense, arouses a critical mind rather than stifling it. The Enlightenment and Condorcet both illustrate and defend this idea of progress. But progress then became an ideology, as "an all-encompassing idea which endeavours not to exclude anything, which tries to explain everything and which is formed in such a way that it cannot be refuted", (according to the definition given by K. Popper). How better to illustrate this ideology than with this Flaubert quotation, to Homais, "All the problems of humanity will soon be resolved as we are living in the age of science" (Homais, the pharmacist in *Madame Bovary*). The end of the 19th Century and the start of the 20th (the Great War would certainly change a lot) saw this "Great Illusion", "It took thirty years for science to discover the nature and origin of all the great endemics which seemed to stop civilisation at the threshold of tropical countries. All the problems are outlined, all the solutions are foreseeable. The governors of our colonies think as men of science and act as administrators to apply the doctrines born in Pasteur's time. Our Colonial Health Corps continues its admirable work everywhere it goes", wrote Naltan-Larrier in 1915 (Quoted by B. Latour, *The Pasteurization of France*).

This growing strength of science and technology throughout the 20th century has had an impact on what can be called the domain of 'human affairs management', with the formation of a 'technocracy'. The links in the technological network have gradually tightened and have left less and less room for politics, "From the end of the 19th century, we have witnessed a scientificisation of technology [...] The dynamic immanent in this progress seemed to produce objective restrictions with which a policy meeting functional needs must conform" (J. Habermas, *Technology and Science as Ideology*, 1968). And, the fateful consequence, we are witnessing the "Disappearance of the difference between rational activity with regards to an end and interaction in the conscience of men themselves", reducing resistive capacity against this seemingly unstoppable rise of the technocracy.

One of the great hopes of this technocracy has been to promote prevention as a new way to fight against the risks, replacing what had until now been the only possibility; foresight. Foresight was the traditional way to protect against risk. It essentially amounted to savings that could be used to react after the risk had occurred. With prevention, everything changes. Prevention is a new approach based on science and statistics. It calculates the frequency of accident occurrence, looking at the causes it analyses and offers solutions to avoid them. It should then be possible, with this information, to eradicate all risk by taking measures before they occur.

If, of course, prevention is an effective and necessary approach to defending against risk, it still doesn't allow for the eradication of all risk. And generally speaking, science cannot bring mankind everything it expects and hopes for from a successful life. But this insight at the very limits of what science allows, calls for us not to be trapped by this ideology. Cournot has analysed its results, "Of all those relating to the order of natural events, none is closer to the family of religious ideas than the idea of progress (and therefore the idea of the divine) [...]. Neither should it come as a surprise that devotion feeds off this and that the maxim which tends to corrupt all religions, namely that the excellence of the end justifies the means, also corrupts the religion of progress" (Cournot, *Considérations sur la marche des idées et des événements dans les temps modernes (Considerations on the progress of ideas and events in modern times, 1872)*).

The foundations of this 'science empire' were soon shaken to their core... Several important events contributed to this, some on the periphery of science, others at its very heart: closer relations to technological theory, the power of the market, and the uncertainty that has recently taken residence at the very heart of science.

The first event, which seemed to be to the advantage of science, has been its closer relations to technological theory. For a long time, until the end of the 19th century, science and technology were separate, with technological theory being composed mainly of empirical foundations. And, for example, thermodynamics (Carnot, 1824) as a science came after the invention of the steam engine (Watt, 1769) to which it gave its theoretical basis.

The tipping point that technological theory found in science took it to the next level, first simply defined as a 'knowledge which enables one to achieve a result in the world' to modern technology, 'a set of powers founded on science'. This scientificisation of technological theory vividly demonstrated the value of science and finally met the needs that had been expressed since the dawn of modernity (Descartes, Bacon). The most striking illustration of what we today call technoscience (Hottos), a complete integration of science and technology, is given by nanotechnology. This technology led to, "The blurring of the boundaries between sciences and technologies, between inert and living materials, between natural and artificial, between knowledge and goods, between man and machine, between subject and object, between the virtual and the actual", according to B. Bensaute-Vincent.

Another consequence has resulted from this merging of science and technology. In showing its capacity to support the creation of objects that could be the subject of financial transactions, science has now handed itself over to the market empire. It came in through a field created by power struggles where it soon appeared weak. Science, accustomed to living on very little, in an independent manner, had to learn to live with greater financial needs (laboratories don't come cheap). It had to submit to demands, or at least the expectations which weren't necessarily its own. We see how science, captured by the market, has become a major issue for the economy and industry, a financial issue and even for political power it represents the power itself, as it is for this very power that its decisions are made. The scientificisation of technology has been a Pyrrhic victory. If science imposed its language on technology, it has ended up by losing its power and independence, and now finds itself entangled in balances of power.

A second event, in continuation of the first, has been the lost innocence of science. Here follows an anecdote that illustrates this; the meeting between Bohr and Heisenberg in 1943. Heisenberg, who was leading fundamental matter research in Nazi Germany, went to meet Bohr in Sweden. He wanted to tell him that German scientists would voluntarily halt research so as not to allow Hitler to rapidly manufacture and deploy nuclear weaponry. But, in the climate of general distrust that prevailed at the time, he didn't dare express himself clearly enough, and Bohr didn't understand his approach. He failed to mention, in particular, that Hitler would be able to access the technology allowing him to perfect this fatal weapon, and hurried over to the United States to give his services to the American power... The tragic paradox being that Hitler would never use a nuclear bomb as it was never completed before his defeat, while the Americans dropped two of these terrible weapons over Japan. It appears here with the greatest clarity that the scientist was overruled by the citizen; it is no longer possible to separate the two 'roles' in any given person, scientists can no longer reclaim their neutrality to continue research without worrying about the consequences that could arise. The nuclear bomb is a direct consequence of fundamental research into the structure of matter.

Another event, this time within the confines of the scientific world, would have as big an impact on its status and image; uncertainty, which science should have saved us from, came to take residence at its very core. First there was Heisenberg's principle of uncertainty (1927) which highlighted the limits of determinism (and thus, of foresight): these principles state that it is impossible to know both the position and speed of a particle, and that mankind could never reach this vantage point that Laplace

promised, the point at which the future would become accessible through calculation. As P. Langevin states, "when faced with uncertainty, our entire mental system needs reviewing".

An essential distinction has also emerged during the 20th century: that between 'complex and 'complicated'. Complicated is that which can be broken down into basic units (even if that isn't always easy!). In contrast, a system is complex when there can be no further breakdown of elements from the complex whole in a system based on basic units. We can define as complex any phenomenon which involves a difference in level and a circularity between these levels (recursion). And recursion that affects the functioning of its components ("they are transformed as they function"), gives rise to phenomena of emergence, which are certainly understandable but not always predictable. If it is possible to precisely direct the development of a 'complicated' system using a master of its basic units, it is still very difficult, even impossible, to control the development of a complex system (even in the best cases, there is always room for an element of 'surprise').

On this basis, establishing the limits of determinism in globalised visions, new theories are developed (the Lorenz theory of chaos, with the famous 'butterfly effect', the fractal geometry of Mandelbrot with the equally famous image of the Brittany coast that that has been the subject of attempts to accurately measure). These theories state the unpredictability of the future. It cannot be calculated; a measure of uncertainty is our fate and always will be. "The paths of nature cannot be predicted with certainty; an element of chance is unavoidable and far more decisive than Aristotle himself realised: a bifurcating nature is one where small differences, insignificant fluctuations, can, if they occur in opportune circumstances, invade the whole system and create a new regime of functioning" (I. Prigogine and I. Stengers, *La nouvelle alliance (The New Alliance)*, 1979).

What stage are we at? Let us take stock of our present situation. Have we witnessed the dying embers of technocratic power? In any case, we have entered an age of distrust, and science has not been spared. Our new horizon is full of uncertainty and major risks. We are witnessing a shift from the idea of progress. We are entering a time, which will be the subject of my second part, of precaution.

Are we to believe that technocracy and positivism are fading with their dying embers? It is certain that the crisis we have seen at the beginning of the 21st century has revived questions of a practical nature, particularly that of the meaning of progress, an issue that falls outside the boundaries of technocracy. In effect, the technocratic system creates a mask between issues of a technical nature and those of a practical nature (replacing the question 'how would we like to live?' with 'what do we want to have to live?'). Moreover, in these circumstances, scientific positivism is proving to be restrictive and deceiving. As Husserl put it, "This science has nothing to say to us. It excludes in principle precisely the questions which man finds the most burning: [...] questions of the meaning or meaninglessness of the whole of this human existence".

Another characteristic point of our age is that we have entered an age of great distrust towards decision-makers and 'leaders' in general: the unfulfilled promises of progress (with, in particular, the failure of prevention), social division, financial extravagance (the subprime crisis of 2008) can be held partly responsible. But science has not been spared. Its image is more ambivalent than ever. Like a coin, it has two sides, and these two sides cannot be separated. This is illustrated very well by today's nanotechnology. But, and this is independent of the above, science is also the subject of scandal. Even if it isn't the only one to blame, it is in part on science that the blame falls for the contaminated blood affair (1976) and the handling of the BSE crisis (1996). Science and scientists have endangered public health by obeying their personal and selfish considerations. And even when it is not suspected of compromise, science has fallen from its pedestal when it turns out to be incapable of coping with new risks. The science of these 'new risks' is in its infancy, as we can see in the domain of public health with the almost complete lack of knowledge relating to links between cancer and the

environment. From all this forms a deeply troubled image. An image of science (science can be used for both good and bad), and also that of scientists. The scientist in the laboratory appears cut off from the 'real' world, and the expert is fallible even in their very knowledge. But the expert can also be 'bought' by the power of money, and is increasingly placed into 'conflict of interest' positions.

Is there a hope that science will return to a supposed original 'purity'? In reality, it does seem that the link between science and society cannot be broken. We can look at epistemological reasons for this. As Putnam wrote, "What the world of physics leaves aside is the very thing which makes the world possible for us [...], namely intentional, evaluative work, a framework for 'synthesis'. In a word, without values there would be no world". But there are also sociological reasons: through its relationship with technology, science is also linked to money as there is a great need for financial resources to carry out research. The balances of strength and reason seem to be inseparable. This idea is central in the philosophy of B. Latour, "We sought to demonstrate the 'influence' society could have over the evolution of scientific theories and technological progress [...] and came to the conclusion that 'the sciences' had indeed to be separated from 'politics'. We had run off course and therefore had to come back a few steps. It was at the very beginning, when separating balances of power from balances of reason, that we had been mistaken".

A new horizon appeared - Uncertainty, related to major risks, without being able to put ourselves in the hands of a protector who we could put our trust in. "Modern technology has turned into a threat, and the new land of collective practice in which we find ourselves with cutting-edge technology is still bare in terms of ethical theory", writes H. Jonas, who gives the following explanation, "The extension of power is also the extension of its effects in the future [...] The length of the foresight should ideally be equal to the length of the chain of consequences. Equal knowledge of the future, though, is impossible". This is why "a new science is required for all of this, one which would deal with the staggering complexity of interdependences. In the meantime [...] *prudence* is the better part of valor [...] It could be that uncertainty is our permanent destiny, *which has moral consequences*".

We see a swaying away from the idea of progress, more precisely from its ideology. At the origin of this ideology we find the premise of a dialectical transformation from bad to good; dialectic no longer applies. There are three primary causes. The first being the collapse of the idea of totality, then the experience of evil in the 20th Century and finally a mutation of the philosophy of action. The consequences are increasingly defying intentions. Everything appears as if the dialectic were now working in the opposite direction - what seemed to be good is transformed into evil in the end.

Part 2: Entrance into the world of precaution

In the second part, I propose a 'Weltanschauung' on the state of the world today. I have four proposals in particular to set us on the way to a world of precaution. We need to change our relationship with nature, develop greater rationality and develop a new perception of action. But we

also need to opt for ethical pluralism with prudence as its real linchpin, which we need to increase today in the context of a world which has become fragile, complex and uncertain, which I will define as precaution. I will show that science is particularly significant in this necessary transformation.

We are experiencing a multi-faceted crisis; a crisis in our relationship with nature, a crisis of reason [the type of rationality exhibited in the 19th and 20th centuries no longer works], a crisis of action. We therefore live in a world which has become 'fragile, complex and uncertain'. The old means of development is no longer suitable and we need a 'change of regime'.

Our relationship with nature has become purely instrumental, and science is partly responsible, "Modern experimental sciences have been used since the time of Galileo in a methodological reference system which reflects the transcendental perspective of a possibility of technologically disposing of things. This is why modern sciences breed a knowledge which, in its very essence, is a technologically usable knowledge".

A crisis of reason - the type of rationality exhibited in the 19th and 20th centuries no longer works. As M. Weber explained, in this period we saw the explosion of the concept of reason: instrumental reason and value-based reason, into instrumental reason and valued reason [into the Zweck and Wert rationalities]. And Weber reminds us, "The destiny of our era characterised by rationalisation [...] and above all by the disenchantment of the world, [which] has led humans to banish the most sublime supreme values of public life", before concluding, "Which god do we need to serve among all those who are fighting against each other?"

It is therefore a crisis of action. The liberal model of action has reached its limits. "The effort on the part of each individual to improve their condition, when you allow such effort to develop with freedom and confidence, is such a powerful principle that it can solely, with no assistance, not only drive the society to prosperity and opulence, but also overcome a thousand absurd obstacles, including the foolishness of the human laws which often hinders its progress.", wrote A. Smith (*The Wealth of Nations*, 1776). But can we still reason in this way today? Actions which are not well thought out, or not thought out at all, which Smith gives as a model, completely ignore the indirect effects, both distant and cumulative. These effects are at the origin of most of the evil which we know today. This lack of reflection leads to the risk of forgetting the aims, or an inversion of the aims and means. This is something which we sometimes see in hospitals where a great effort is made to implement significant technical resources, more for medical performance than the good of the person who 'benefits' from them. The action that Smith proposes is also a 'loosened' action. There is no coordination between parties (if not carried out by a market intermediary). Smith counts on his famous 'invisible hand' to coordinate everything. But we clearly see that this invisible hand fails to fill the role which one would like to see it have.

A crisis of our relationship with nature, a crisis of reason, a crisis of action: precaution and the precautionary principle seek to provide a response to these 3 crises.

A change in our relationship with nature is therefore necessary. This change needs to be cognitive. The contribution of ecology is essential here, ecology teaches us to understand nature in relations and complexity. It also needs to be affective. We need to develop appropriate feelings towards nature. But is this possible without an authentic experience of nature? These are the changes which underlay the idea of the “natural contract” of M. Serres, who aims to make us move from a relationship of domination to a relationship of domination with nature.

We need to move towards greater rationality. We have to reinvent reason in the 21st Century as B. Saint-Sernin invites us, “In order to prepare for the third millennium we need to rebuild, in an entirely new way, the broken link between what Kant called theoretical reason and practical reason, between knowledge and awareness”.

This rationality owes a great deal to practical reason. Let us remember that if theoretical reason has the aim of producing ideas, the aim of practical reason is to produce actions. These two reasons have come closer together, even mixed (technoscience), and we can define scientism by the pretention of theoretical reason to attribute all reason to itself.

But a return to Aristotle, and particularly to his perception of practical reason, has been observed since the 1950s. “The invasion of the objectifying methods of modern science [...] appeared as the consequence of a false objectification. For moral knowledge, as Aristotle describes it, is clearly not objective knowledge: the knower is not standing over a situation that he merely observes. He is directly confronted with what he sees. It is something that he has to do”, writes Gadamer, who advocated this return to Aristotle. Putnam’s pragmatism is also a particularly interesting source, “Putnam [...] recognises the reasonable authority of science [but] opposes it in order to make way for practical reason, for the scientific autonomisation of this authority. The authority of experience, common sense and morale are also conducive to reason”, wrote Habermas. This increased rationality should also be responsible for what Rawls called “reasonable”. “Reasonable persons, we say, [...] desire for its own good a social world in which they, as free and equal, can cooperate with others on terms they can all accept. They insist that reciprocity should hold within that world and, “many of our most important judgements are made under conditions where it is not to be expected that conscientious persons with full powers of reason, even after free discussion, will arrive at the same conclusion [...] Taking such difficulties of judgement into consideration is of the utmost importance to a democratic perception of tolerance”. A very different image emerges than the scholar or philosopher who in the solitude of his sanctum, thinks of the world with just his own mind. The only reason which seems appropriate today is a collective reason... and one which is more modest. B. Saint-Sernin describes it thus in his *La raison au XXI^{ème} siècle* (Reason in the 21st Century), “In other words, the form of unity of reason that the Enlightenment movement claimed to represent is dead. We must conceive and institute its unity differently, through the interaction of free spirits who know that this new rationality will inevitably include a combination of *theoria* and *doxa*, science and belief

with more or less solid foundations. It will therefore include, in human terms, an element of uncertainty and risk”.

We also need a new perception of action. We need to enrich our perception of action. For this it is interesting to look to Aristotle who designed three groups of human actions, “Any application of thought is either practical, poietic or theoretical” (Aristotle, *Metaphysics*, E1). I have taken up this idea in the form of a triangle (the “triangle of action”, with three points: *poiesis*, *theoria*, *praxis*). Historically, with the advent of economic liberalism, action has become unbalanced. *Praxis* (generally politics) has lost much of its importance, *theoria* (thoughts and reflection in general) has fallen prey to *poiesis* (production in the economic sense), which has come to occupy almost all of the ground alone. But action cannot be reduced to the sphere of production. It must also contain a thought, real reflection (*theoria*: a well-considered action - having the ‘intelligence of purpose’ to always put yourself in a general context, having the ‘intelligence of means’ to always be very aware of the singularity of the situation, of the context). It also has to be a related action (*praxis*: a liaison between the players in production; liaison between intellectuals, producers and users). It is essential to link action. It is true that a holistic approach is necessary to reach a satisfactory result. Optimising the whole is very different to carrying out a simple summation of optimisation of the parts! When living, thinking and working in a network, isolated action is no longer possible. A decisive issue is the quality of the relationships between players.

Today, balanced action needs to be carried out through an exchange, communication, continued deliberation between producers, scientists and citizens.

I would now like to show that the only appropriate ethic is pluralist. Faced with complexity and uncertainty, ethical pluralism is required. The major systems fail to explain today’s world. The trial and error, experimentation and analysis-based approach in return for experience seems more appropriate. Shouldn’t ethics also adapt to reflect this regime? I agree with M. Canto when she says, “As morality is a complex and heterogeneous phenomenon, it would not be at all intellectually surprising if several moral perspectives were required to analyse it”. But what form does this multidimensional ethic take? First of all it must have a deontological dimension. There is a new imperative in fact, as explained by H. Jonas, “Act in a way that the effects of your action are compatible with the permanence of an authentically human life on Earth”. It needs a consequentialist dimension. It is no longer possible not to be interested in the consequences, in particular the distant consequences of our actions. This consequentialism is necessary, but not sufficient. “Future responsibility extends as far as do the future consequences of the action committed or omitted in the present”, writes Birnbacher, but, “[At the point where the maquis of the distant future becomes impenetrable, risk calculations lose all meaning]”. The realisation of the consequences soon finds its limits in a world where the future holds so much uncertainty, but that does not stop us from committing to the long-term, to drawing up different scenarios based on a probability. It goes as far as being a duty for us (our consequentialist duty).

It finally needs a 'virtue dimension'. In a chaotic world, isn't the most important thing the quality of people, which provides a group with the ability to react to unexpected situations, not to give in to fear, to remain lucid, to maintain a collective dimension for action? Virtue brings out the best in a person's nature, "Virtue is a disposition to act in a conscious manner consisting of a mediacy relating to ourselves, which is determined rationally and as a prudent man would determine it" (EN, II, 6). Which virtues should we develop? Without listing them all, I would like to emphasise the importance of some character virtues and intellectual virtues. Courage and liberality, the holders of which Aristotle described as, "He who waits steadfastly and fears the things he should, with a specific purpose, in a way which is appropriate and at the appropriate time, or who demonstrates confidence under the same conditions, is a courageous man", and for the liberal man, "[he who] will give and expend for the things he needs and insofar as is necessary [...] [and who] will only take from lawful sources and in appropriate measure". As for intellectual virtues, I would like to emphasise the importance in our world of intelligence (the ability to resolve specific situations), judgement (the appropriate discrimination of what is just), reflective balance (being able to correct intuition using rules and rules using intuition). Finally, I will add the virtues of discussion - being open to others' ideas, being attentive, and having just conviction in the expression of one's ideas. But the truly essential virtue is prudence. Aristotle tells us that it is an intellectual virtue which regulates moral virtues. It is a virtue which is deeply marked by an awareness of the limits of our knowledge. Also a prudent man is one of deliberation, "Deliberation is employed in matters which, though subject to rules that generally hold good, are uncertain in their issue; or where the issue is indeterminate, and where, when the matter is important, we take others into our deliberations, distrusting our own capacity to decide." (EN, III, 5).

What about ethical pluralism? One cannot apply principles without some concern for the consequences, one cannot simply calculate the consequences without taking the principles into account. There is a greater need now than ever for virtues, including those of discussion, the most fundamental being that of prudence. We can also note that to some extent, prudence is all-encompassing in relation to other virtues, and even, from a pluralist perspective, in relation to other schools of ethics. Indeed, is it not prudent not to forget the principles and to have some concern for the consequences? One might even go so far as to say that pluralist ethics are absorbed by ethics of prudence – except that today we must add precaution to prudence making precaution our new prudence.

But why lengthen the list of virtues by adding precaution to prudence? Shouldn't we use the principle of Occam's razor here? I plead in favour of the idea that precaution is really our new prudence. It is distinguished while simultaneously resembling it, and it is conceptually necessary. First of all, there is a semantic distinction between the two. Prudence is for oneself or for those around you (We say "Be careful!" when we want someone to be prudent). Precaution is for others and the world around you [we say "Beware!" to when informing others to take precaution from potential harm). This is a distinction which is heavy with meaning today; we need to act with

precaution towards the world and towards nature. This is a new concern for us, in a Heideggerian sense. In short, precaution, our new prudence, guides our actions in a fragile, complex and uncertain world. It enables us to establish a new relationship with nature, a new way of thinking and a balancing of our actions. It is the form our responsibility needs to take in an age of technological 'overbearing'.

Where does science fit into all this? Should it be isolated? Return to the ivory tower? It is the temptation to withdraw [the Venetian Temptation]. Educational authorities are in favour of this, but it is impossible and makes no sense! It needs to first of all become aware of the limits of a science which is understood to be purely objective. A science which wishes to be purely objective will never really be so (as we have seen earlier), and if it were theoretically possible, this would only be at the cost of a considerable impoverishment of reality, "There exists a threshold between the world we experience and the objective world [...] When we abandon the point of view of the participant in the practices of the world we experience to adopt that of an observer who is focusing on something in the objective world, we are allowing the normativity which characterises all intellectual activities to escape". A more modest science does not mean a science which is less present. "If we need less Science, we need to count much more on the sciences; if we need fewer indisputable facts, we need much more research; if we need fewer raw qualities, we need much more collective experimentation on what is essential and what is accessory". What is of principal importance is making science reflexive, rediscovering to what extent scientific discussions are set in the contexts of the world we experience, "If the scientific self-comprehension of the sciences is wrong, it is primarily because it is unaware of the setting of the practice of research on a horizon [...] Without values, there would be no world" (Putnam, in *Realism with a Human Face*, 1994) Making them reflexive and making them enter society in the best possible way, not subjecting them to lobbying, but allowing them to "enter democracy". "[It was simply a question of] bringing the sciences into democracy. Throughout this book, I have had to propose this solution whilst using outmoded terms such as speech, discussion, Constitution, Parliament, chamber, *logos* and *demos*. If we have to call upon negotiators it is precisely because there is no Sirius point of view". We will see that the principle of precaution is a remarkable step in this direction.

Part 3: The Precautionary Principle – an ethical principle
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All that remains for me now is to present the precautionary principle, and to show what a deliberative principle is, a reasonable principle, a principle of action and finally an ethical principle. I will spend some time on the latter, which will also be my conclusion.

The precautionary principle is a very controversial principle! Even though it came about in Germany in the 1970s, it was in 1992 that it fully came into the limelight, on the double occasion of the Rio Earth Summit and in Europe with the Treaty of Maastricht. But it has also been strongly contested, on a global level in a Nobel Prize assembly declaration (The Heidelberg Declaration in 1992), and on a national level by the academies, in particular the Academy of Medicine. It was criticised for being a principle of inaction could be expressed as the refusal of any risk or a pathological pursuit of safety, a lack of courage, an ignorance of life. In basic terms, it would be a principle defended by 'fanatics, obscurantists and enemies of progress', etc.

But what does this principle mean? I will provide two definitions. The first; "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation", which is article 15 of the *Rio Declaration*. The second, which has been developed more; "When damage has been done, even where it is uncertain according to current scientific knowledge that it might affect the environment in a serious and irreversible manner, the public authorities shall ensure, by application of the precautionary principle and in their areas of responsibility, the implementation of risk assessment procedures and the adoption of provisional and proportionate measures in order to avoid the occurrence of the damage", which is article 5 of the *French Constitution, Environmental Charter*. I will come back to these definitions, but we can clearly see in reading them that the catastrophic interpretations of the precautionary principle simply do not fit! First of all we need a framework.

To start with, there is this essential distinction, which is unfortunately very seldom understood: the distinction between prevention and precaution. In fact we need to distinguish between three degrees of uncertainty. Risk, uncertain and indeterminate. There is a risk when hazard can be probabilised, where we have scientific knowledge of the situation and we can calculate the relative probability of its occurrence. A risk situation calls on prevention measures (there is a whole scientific dossier which we can use to chose the most effective measures). As for the uncertain and the indeterminate, they correspond to situations where this scientific knowledge is missing, and where it is not therefore possible to calculate the probability relative to the occurrence of the risk happening. The difference between the two is that in the case of the uncertain we know of the set of possible situations, while in the case of the indeterminate we do not know this set (incertitude is not just about the probability of an event occurring, but the very nature of the events. A surprise is possible). In these two cases (uncertain, indeterminate) the risk situation calls for precaution; the scientific dossier which we would like to rely on to choose the most effective measures is incomplete.

Then there is this second distinction often pointed to by numerous authors who have written on the Precautionary Principle. I propose to systematize these between the Precautionary Principle and what I call "the" precaution. This distinction rests upon another - between risks and effects. If we

consider a technological innovation, nanotechnology for example, this innovation is going to bring about a certain number of effects. Amongst these are the effects that we fear: risks, but also other effects that are more or less "invisible" - economic, social or even philosophical effects. The risks are only a part of the effects. For nanotechnology there are health risks through the entry of nano-particles into the human body - specifically into the brain where they could accumulate. But there are also effects that do not present themselves to us as risks in the strict sense of the term but are, nevertheless, contributors to wider-reaching changes.

Ontological effects with the artefact and the virtual prevail. What experiences do we make with nanotechnologies? Are we not going to be led to consider that the being is 'what we have created'? The passive will be wiped out before the active - nature would no longer be what we receive as a donation, but the product of our will. There are also the metaphysical effects of nanotechnologies, with the displacement of large categories: the natural non-living, the living and the artifact tending fuse together. One also sees the existence of limits being put into action: are there no longer limits on the will and power of man to fashion a world entirely according to his desire? Furthermore there are epistemic effects: we are not going towards a truth without transcendence: '*Verum et factum convertuntur*', (the true and the made are interchangeable) as Vico declared at the start of the 18th Century? Another effect could be the contempt for the observation sciences ('natural' sciences) that appear to be "obsolete" in relation to what man is able to create in laboratories. I also propose to further distinguish between precaution and the Precautionary Principle. Faced with all the possible effects of our actions *precaution* is a general and permanent attitude when faced with effects that are uncertain risks. *The Precautionary Principle* is a singular decision. The Precautionary Principle also makes up a part, but only a part, of precaution.

I am now going to turn towards the content and the application of the Precautionary Principle. To begin with it is necessary to set out the double objective of this: to protect, as it is possible to do so, the "new" risks (linked to the progress of science and techniques). But the precautionary principle is also aimed at favoring an apprehension and collective assumption of these new risks, (it is the question of acceptability). The Precautionary Principle allows to pass from a notion of "risks they are subjected to" to "acceptable risks" or even "consented risks". As for its area of application, it primarily concerns the environment (this is its original domain), but it has come to link with health (official recognition of this fact coming from a 1998 ECJ Judgment) food (taken up again and developed in the 2002 EC Regulation on food in the EU) and, more generally all the consequences that technological innovation has on this area and in particular how these are spread on a large scale by the market economy. Now, when we call upon this principle, what does this engage? This is a very important point since the Precautionary Principle cannot be engaged just for anything. Its use must be linked to the existence of risks, whether these be "serious and irreversible"; collective and often differentiated or, finally, *uncertain risks*. With regard to its content, it contains three essential points. These are: an evaluation of the risks, the adopting of measures that are "proportionate and provisional" measures and also excellent communication between information, transparency and the involvement of civil society.

But more precisely, how do we choose the measures engaged by the Precautionary Principle? We too often assimilate the Precautionary Principle and the adoption of extreme measures (bans, for example). Certainly, the Precautionary Principle can lead to the adoption of these sorts of measures.

But, in fact, a range of measures exist. One can act by launching research, a basic alert, a moratorium, a provisional ban or a definitive ban. But the measures taken, (and the texts are insistent on this), must be proportionate. But proportionate to what? One cannot apply a mathematical proportion, as the elements of knowledge that allow to establish this proportionality are lacking. But the elements too, outside of those mathematical resources, establish that such proportionalities are present. The main elements allowing for this proportionality are: the supposed gravity of the damage feared; the level of security sought; the cost of planned measures and the characteristics of the hypotheses. If it is not a mathematical calculation that allows for establishing the proportionality, it is certainly not arbitrary! One has to call upon all resources of reason that do not reduce scientific rationality. Deliberation is essential as the Precautionary Principle is a deliberative and reasonable principle, not a guillotine!

Who now decides on proportionality? This question is crucial. In all cases, deliberation is essential. Fundamentally, the Precautionary Principle is a deliberative principle. Assessing risks, choosing measures, communicating - all of this requires deliberation. Risk assessment is, already, a cooperative process. Rapprochement is possible here with pragmatic research logic. According to Putman "the research process is itself is a case of social cooperation. [...] There is an internal link between the practice of research and contexts [...], which is essential to the rational carrying out of scientific research and therefore, to a certain extent, essential to the intelligent performance of any cooperative activity". The choice of measures also calls upon deliberation. If it is true that "There exists a threshold between the world we experience and the objective world [...] (that) when we abandon the point of view of the participant in the practices of the world we experience to adopt that of an observer who is focusing on something in the objective world, we are allowing the normativity which characterizes all intellectual activities to escape". Therefore to reintegrate this normativity of practice, we need to open up our expertise and we need pluralist expertise. Finally for communication, one has to understand "communication" in its largest possible sense. Communication is interaction in the Habermasian sense. This communication also passes by deliberation (Habermas, *Morale and communication*, 1983).

It remains to be explained how the Precautionary Principle is a reasonable principle, an action principle and finally an ethical principle. In this sense it is reasonable that it is as much a theoretical reason as a practical reason. With a theoretical reason the Precautionary Principle does not demand a break with scientific reason. But it asks to take a step back towards the notion of scientific testing. It is particularly necessary to insist upon the existence of radical uncertainties and the importance, even in the practice of science, of extra scientific choices. With a practical reason, it insists upon the need to take the values and purposes of human action into consideration (the example of the Precautionary Principle applied to GMOs) Also, it is reasonable in the Rawlsian sense as it is the search for a common answer with a concern for cooperation and justice that is aware of the limits of our knowledge and therefore puts oneself in a modest position.

The Precautionary Principle is also a principle of action. It is a principle of action if we take the complete action - the action being structured around its three axes. The precautionary principle contains poiesis, as it is not a case of abandoning the production of objects and goods; theoria, as it

is necessary to research and reflect a lot when it comes to technological innovation; and finally praxis as all levels require social cooperation on all levels (research, choice of measures, communication, etc.)

And finally the Precautionary Principle is an ethical principle. It is an ethical principle, since it leads us to seek a fair measure to implement when faced with risks, which must enable us if not to create a good life (this would rather be the object of extended precaution in the sense given above) then at least to avoid great evil. It is an ethical principle because it is an eminently responsible principle.

If it comes to be that there is a cardinal value for science in terms of the truth, utility, to progress what relationship will it have with these? Are they ousted or does one keep them as associated values? Its relationship with the truth consists first of all of establishing a distance: it is about not waiting for the truth to act; to persuade yourself that there is not an absolute truth and that truth is always contextual. But that being so, the truth remains an essential value! And in particular, one must refuse the "little arrangements with the truth" that are so tempting when we want to hide, or on the contrary promote, the singular results to their research. These little arrangements can turn out to be dreadful pitfalls. When they are discovered, they lead to a loss of credibility that extends right across the work in as much as it is true that one loses confidence much quicker than they win it. The current disappointments of the IPCC perfectly illustrate this situation.

Its relationship with utility: with precaution it is less about looking for the best (in the sense of the most useful) as refusing the worst. Even if it was possible to imagine a technical process that allows for efficient water purification, the precaution will request that we do everything to save nature and the ecological service that she provides herself and the waste water that we give back. Preserving the richness of nature before your eyes, on a technological utopia in which one could establish that it is more efficient - but at the price of destroying this nature.

Finally, the progress report. Progress, when it functions as an ideology via technological innovation "smoothes out" these 2 questions, but is it really useful? Is it the aim of true preferences? "It is progress. It is enough to adapt itself. It is necessarily a good thing". Is this enough to quieten down all the questions? From this point of view, precaution is a true rupture. It reintroduces questioning and hesitation. We weigh up to pros and cons but, especially, if there is agreement as to serious risks and scientific uncertainty, let's not rush! We do not play "Russian Roulette" where such things are at stake! Lets us take the time to conduct deep research, to involve all the actors in reflection and move on to a co-construction of the project attempting to build on experience and proceed learning from experience. Precaution appears here as an antinomic with progress and ideology and probably introduces us to renewed vision of progress - where this is understood as human progress and not in terms of progression of the PIB.

For all these reasons precaution seems to me to have to be the cardinal value of science and scientists at the start of the 21st Century. For a young doctoral student entering research is there a more exciting prospect than working in this great "research market" where funding determines the main criteria for the choices that they must make?

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