These few lines were originally written in French as a solicited presentation in a symposium entitled “Creativity in the University, Arts and Sciences” at the Université Laval in Québec. As I develop in this short text, my own experience first and foremost as a scientist (I received the Nobel Prize in Medicine & Physiology in 1977) and later as a painter in the early uses of the digital world (I had a one-man show at the Harwood Museum in Taos, NM, in 2004) has led me to recognize both similarities and contrasts in the ways of thinking and practicing in arts and science. A suggested list of highly pertinent additional readings is included at the end of this short text.

It is necessary first, if not to define, at least to indicate my connections to the milieux called sciences and those called arts.

My knowledge and scientific contributions have been in the domain of biology, to be more precise, in order of greater and greater specialization: 1) in medicine, 2) experimental medicine, 3) physiology, 4) endocrinology, 5) neuroendocrinology. After briefly practicing medicine in a small village in Bourgogne, I took a doctorate in sciences with Hans Selye...
produced in the non-virtual world in the “computer paintings,” which are then available for other purposes (see above). My contribution to the arts, as I see it, is to create de novo, in the virtual universe of the electronic machine, what I call “computer paintings,” which are then produced in the non-virtual world in the form of classical lithographs or prints of very high resolution on paper or canvas, either as unique images or in limited editions (see Color Plate B and Figs 1–4). My style, my imagery, if I dare to say it, is of the fashion one calls abstract expressionism in the vein of Jackson Pollock, Robert Motherwell, Helen Frankenthaler, Larry Rivers and many others of New York and elsewhere. Besides the method that I have introduced, the engravings and canvases that I make are my artistic contributions.

Scene(s) and actor(s) being thus placed, we return to the title of this short presentation. I limit myself, to be precise, to discussing only the manner of working (the process) in the sciences and the arts, from the view of my particular practice. I will not speak at all of the great problems these have of the significance or cultural value of the sciences and the arts, nor the contributions of each to the other(s). We will thus be essentially “practitioners.”

**Similarities:** I have been very surprised by the astonishing similarities between the intellectual procedures of the sciences and the arts. In the experimental science that I have practiced, one attempts to establish facts that will be recognized as being universal and indubitable. One starts with a working hypothesis, based in general on prior observations, that one tests: a region of the brain (the hypothalamus) seems to be implicated in the control of the central endocrine gland called the hypophysis or pituitary and probably not by the nerve fibers as one might expect, but probably by means of very particular intermediary capillaries that run from the brain to the gland in question. One who says capillaries is implicating circulating blood, and thus, in our case, the presence of chemical substances originating in the brain (hypothalamus), which substances stimulate the hypophysis to secrete its proper hormones. First stage: confirm the hypothesis of humoral control (by the blood) rather than by nerve connections. Let us say that diverse experiments are performed and the results are in accord with the hypothesis, and no experiment gives results that are in disagreement with it: one concludes that one has humoral, not nerve, control.

The second stage will be to prove the hypothesis in a manner that cannot be doubted: what are the hypothetical humoral substances made by the brain (hypothalamus) that stimulate the hypophysis function. It is evident that if one could isolate these, find their chemical structure, then one would be able to synthesize them, demonstrating their presence in the blood within capillaries that run from the brain to the gland, then the working hypothesis will be proven beyond doubt.

If the first stage of our procedure was relatively easy, the second was very difficult and took nearly 10 years. How did we proceed? We decided on a series of experiments, which were carried out. Now the results obtained are not in accord with the hypothesis, but these do not force us to reject it because one or more observations are made that could be explained without rejecting or accepting the hypothesis. We decide on a new set of experiments in which we would change one or many conditions with a view to see what happens. The results this time are totally in accord with the hypothesis in question. After a series of stages of the same sort we isolate only one single substance that satisfies the criteria of the hypothesis. When we have established the molecular structure of the substance in question, have demonstrated its presence in the brain (the hypothalamus), its passage in the blood vessels from the brain to the hypophysis, and confirmed the biological activity of a synthetic version of it, then the hypothesis is replaced by knowledge proven, demonstrated, confirmed, and one could say that the picture is finished.

Things do not always proceed in this manner; at the University of Montreal, then did research in neuroendocrinology and taught physiology at the Baylor College of Medicine in Houston, Texas, for 20 years. I founded and directed the Laboratories of Neuroendocrinology at the Salk Institute for the next 20 years, until I turned over the direction to my younger collaborators in 1990. Note here (a point to which I will return below) that during this period of active scientific research, my laboratories in Texas and California were always in the avant-garde in the use of computers, using them for mathematical statistics or modeling what we did in biology. These, briefly, are my scientific connections.

As for that which concerns my knowledge and contributions to the arts, let us say that my knowledge is that of a relatively cultured person, literary, musical, familiar with the great museums, with an unpretentious family collection of contemporary cancases and prints, pre-Columbian art, and art from Melanesia. My contribution to the arts, as I see it, is to have been one of the earliest to propose the use of computers and programs available for other purposes (see above) to create de novo, in the virtual universe of the electronic machine, what I call “computer paintings,” which are then produced in the non-virtual world in the form of classical lithographs or prints of very high resolution on paper or canvas, either as unique images or in limited editions (see Color Plate B and Figs 1–4).
fashion in experimental sciences. In other studies, we arrived at a hypothesis by a similar process of successive experimental results and had to conclude that all the results of all the experiments and experimental protocols imagined, invented, and realized as a function of the aforesaid hypothesis gave results repeatedly incompatible with the original hypothesis. Scientific epistemology then tells us we must doubt the hypothesis, demands acceptance of the unexpected results (on the condition to be sure that they are not tainted by some error in their acquisition), and then drives us to alter our hypothesis. The starting hypothesis is rejected, modified, a little or more and more; the process recommences. The second version is corroborated, proven, accepted. The picture is finished but it is not the one that had been imagined at the outset.

The steps of the scientific intellect are not very different than those of the artist, the painter in particular. For the great Renaissance classical painters and after, through the Impressionists, the scientific hypothesis is replaced by a very precise mental or sensory image that the painter would like to produce and reproduce on paper, canvas, the wall of a fresco. In these cases, all experience with hands and tools will be used precisely to complete the production of a precise mental image or the reproduction of a view of nature, dead or alive. This art is figurative. If nothing within experience prevents the realization of the production or reproduction as an image, the scene imagined in the mind or seen by the senses at the outset, will be realized and it is that which the painter will sign: the painting is finished. This is the same intellectual process and practice as that described in our first scientific example, where, after some practical delays, the original hypothesis was confirmed, the image that one has in the mind to produce has been produced, as in the case of classical figurative painting.

In the case of non-figurative painting, the intellectual steps of the painter resemble in a surprising fashion the second example of the scientific process described above: the artist will have at the outset a mental image of a scene. But en route, a thought, an observation, inattention, an accident, or a color different than that from the original mental image leads to a new image that the artist accepts for a time. This is stage no. 1; then, probably, there will be stages 2, 3, 4... the image being modified at each stage. This is the equivalent of our changing scientific hypothesis, in view of unexpected experimental results, which is to say not in accord with the original hypothesis. The finished picture, when the painter declares it such, will be different—perhaps very different—than that which the original mental image suggested. This is the same as when we
eventually isolated a substance that the brain made that was exactly the opposite of that for which we began our search. Matisse has described in particularly precise terms the same stages in artistic creativity with their corrective effects as far as the final product is concerned. I am thinking in particular of what he has written about the successive stages, the evolution, of his great triptych La Danse at the Barnes Foundation in Philadelphia. I must acknowledge to have been greatly surprised by these similarities in the manner of proceeding, of thinking, in the laboratory, and in the study of the painter (computer or not).

**Contrasts:** Contrasts in the mental steps of science, of art? They exist, undoubtedly, and are infinitely more important in their respective epistemologies than the similarities that we have recalled. In scientific thinking, from one experimental step to another, as we have said above, there are rules, what one could even call laws, that there is no question of ignoring. Speaking of the macroscopic world of our scale, not the atomic or sub-atomic levels where things are different and not within our scope here, there are laws such as that of gravity, for example: molecules and everything that is made of them, apples, shoes, fish, people, airplanes . . . are subject to gravity or some centrifugal force working according to equations that are well known and that cannot be transgressed or ignored; similarly, a certain sequence of DNA codes for a certain protein and no other; injecting insulin always causes lowering of blood sugar and not the reverse; injection of adrenaline always produces an increase in arterial blood pressure and not the reverse; the reflection of light rays in a parabolic mirror will be a function of the laws of optics that can be represented by mathematical equations, and this reflection will permit or present only those phenomena that can be explained and reproduced, whatever one may wish, as a function of these laws of optics.

I could multiply to infinity this series of examples of scientific exploration to any precision dependent on facts, or arising from unrelated concepts to create a new theory that leads to a new paradigm and to new experiments—for example, that which Einstein made in introducing the new laws of relativity in place of that of Newton’s gravitation.

To continue, there can be no creativity in science without laws, whether they are already established ones, or ones to be established. This also forces us to recognize that scientific knowledge must be universal and cannot be subject to individual, parochial or political interpretations. When I say that the molecular structure of somatostatin established in my laboratory at the Salk Institute is such and such a sequence of amino acids, my affirmation is true throughout the entire world, not just at the Salk Institute. If someone in Quebec, Paris or Tokyo proposes a different structure, one of us is in error. Such an experimental parasite will eventually be recognized as such in the laboratory of one of its protagonists, or it will be necessary for me to recognize the error in my original proposition, which I will have to correct to bring about unanimity, universality in complete confirmation of the proposed structure.

In other words, the absolute and relative value of every scientific statement is the degree to which it is universal to the scientific community. It is thus that scientific knowledge progresses, in the etymological sense of the word.

It is very different in the world of art, and we limit ourselves immediately, in this discussion, to contemporary art and more especially to painting. The similarities in the mental processes of the scientist and the artist that I have mentioned above seem to me to be much less important than the contrasts that I will speak of next.

Now, I have said above that scientific creativity proceeds from the inside by ineluctable rules, but the artistic creativity that I know knows neither rules, still less laws. Interviewed during a grand retrospective of her paintings at the Museum of Modern Art in New York in 1989, Helen Frankenthaler said, “The rule is that there is no rule.” It is this that one sees in Kandinsky, Jackson Pollock, Robert Motherwell, de Kooning as well as others who create what I call abstract expressionism or even more simply abstract art, where the creation of the painting is the image itself, totally non-figurative, which could never represent a natural object or subject, of the world that surrounds us, even if the painter gives a title to the image.

Thus the creativity of the painter, of the artist, is entirely within his imagination and his mastery of the manual, digital or other practical means of choosing to get where he wants to go. No law, no constraint, no intrinsic a priori things constrain him. Neither is there the necessity to accept what a community calls laws, with the exception, occasionally, of some clique whose pronouncements and edicts are as transient as they are precariously founded—nothing compared with the laws of science. *The painter determines his work*, from beginning to end, and it exists for its own sake. This is far from the constraints upon which scientific creativity advances.

Recall that if science discovers factual, conceptual and universal truths as we have seen, all preexist in our world. In contrast, art, abstract art especially, is total, true creation, the origin of which is some image or event in the mind of its creator and him alone, limited only by degrees of originality.

These remarks have responded, I hope, to the title that the organizers of this meeting have proposed. They are far from being exhaustive. Their sole weight, if one can call it that, is in the fact that they have been suggested to me by my own practice, with all its limitations, in the two aspects of the world that for better or worse we call the sciences and the arts.

**P.S.** After writing this short note, I read Consilience, *The Unity of Knowledge,* then the latest work of Edward O. Wilson. Even if totally out of context, I would like to cite this sentence: “The love of complexity without reductionism makes art; the love of complexity with reductionism makes science.” I agree.

**Acknowledgment**

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**Suggested Additional Reading**


