Nº039

Salvador Dalí

Introduction / Einführung:
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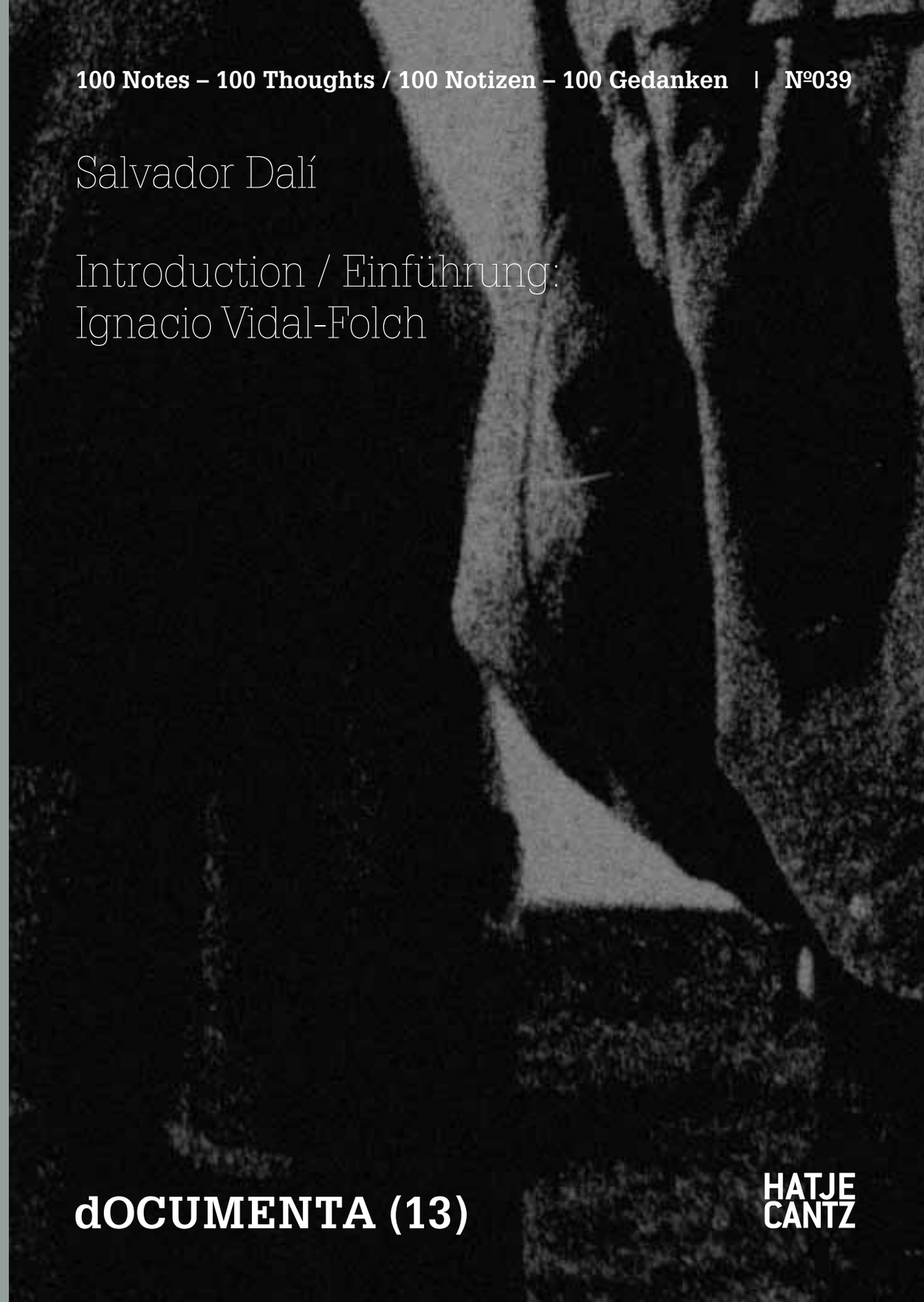


dOCUMENTA (13)

HATJE CANTZ

Ignacio Vidal-Folch

Death, Immortality, and Dalí

The nineteenth-century fascination with scientific advances—especially those of science's friendliest side, medicine, pursuant to the discovery of the miracle drug penicillin—intensified during the twentieth century. Meanwhile, the interest of the masses in literature and the humanities sunk like a grand ocean liner that had run into an iceberg of disappointment. More than by any novel, I myself—a person who does nothing but read and write—have been impressed by the research of Aubrey de Gray, a gerontologist at Cambridge with a picturesque beard, and of other sages who, like de Gray, predict that we will soon be able to put death off for a long time and ultimately be rid of it entirely by halting cellular deterioration. Because, de Gray affirms, it is not inscribed on cells that they must necessarily undergo entropy. Others, like physicist Kevin O'Regan, foresee that in a few hundred years' time, human beings will be able to transport consciousness into a computer. And that computers need not be cold, metallic robots. They might well be organic and sensitive beings akin to clones. The computer scientist and inventor Ray Kurzweil jealously keeps the DNA of his father, Cedric, along with his father's other belongings, in hopes that one day he will be able to create a virtual person very much like his dad.

All that is good news. The bad news is that it is very unlikely that you or I or any of the people we know and care about will live to see any of this happen. The development of immortality requires more time, more investment, more research. On second thought, though, that might not be such bad news: immortality could also be calamitous. After all, in Swift's novel, the Struldbrugs, who are recognized at birth by the red stain on their left eyebrow, and who, after a few centuries of life, show themselves to be "incapable of friendship, and dead to all natural affection," constitute the most painful spectacle to come before Gulliver in all his days. Similarly, in the

Borges story "The Immortal," those who are released from death become, as centuries go by, a bunch of apathetic and forgetful cave dwellers. Homer himself, who is one of them, has forgotten that he wrote the *Odyssey* and behaves, quite frankly, like an ape.

"The highly concrete and serious, the admitted goal of my life, is to achieve immortality for men," affirms Canetti in his notes. A pity! If he had only lived for a few more decades, he would have seen his wish come true. Who knows? Before we achieve immortality, however, the end of the world might be upon us. Not long ago, the great physicist Stephen Hawking repeated his thesis that the only possible way that the human race will survive is if we colonize planets outside our solar system in the relatively short term, which he considers feasible and even likely. He is an optimist. Others, like the novelists Philip Roth and Milan Kundera, are more skeptical:

> Roth: Do you think the destruction of the world is coming soon?
> Kundera: That depends on what you mean by the word "soon."
> R: Tomorrow or the day after.
> K: The feeling that the world is rushing to ruin is an ancient one.
> R: So then we have nothing to worry about.
> K: On the contrary. If a fear has been present in the human mind for ages, there must be something to it.

The truth is we don't really know whether what awaits us around the corner is a birthday cake with a thousand candles or the Apocalypse. We don't even know which is better. The hundredth anniversary of the birth of Cioran was celebrated recently. The best friend of that pessimist with such a great sense of humor was Eugène Ionesco, another Romanian exiled in Paris, who was asked to join the Académie française thanks to his work in theater. Cioran tried to persuade his friend not to join; being an academic, he argued, would degrade and banalize him. It's best to be obscure, anonymous, and marginal, an accursed writer, he said. Besides, the outfits they make you wear to those gala events are ridiculous. Despite those sound arguments, Ionesco was determined to join the Académie. Cioran insisted that he not do it until he realized that his friend was getting annoyed.

When he finally joined the Académie, Ionesco told Cioran, "That's it, I am saved. I am now immortal [members of the Académie are called *immortels*]. And it's forevermore!" Cioran burst his bubble: "No, you can get thrown out. Just remember Pétain, Maurras, Daudet." Ionesco responded with a smile, "So there's still hope?"

Salvador Dalí was an extremely intelligent, cultivated, and imaginative man: a truly original human being. One thing about him that was not at all original, though, was his fear of death, which he shared with all human beings of a certain age. In Dalí's case, the fear of death and interest in immortality set in early due to the particular circumstances surrounding his birth (he had a brother also named Salvador who died just short of age two, nine months before Dalí was born). But it became an obsession after the experiences of the Spanish Civil War and World War II, which divided his intellectual life into two clear parts. The first was dominated by investigation into the psyche through the teachings of Sigmund Freud and the practice of Surrealist aesthetics. And during the second, after his exile in America, he dealt with his fear of death in a classic manner: by converting to Catholicism ("I am Catholic, Apostolic, Roman, and Romanian," he stated grandly on the occasion of the publication of *Sí* in Bucharest, a milestone for which Dalí changed the publication's title to the more opportunistic, cynical, and jocular *Sí a Romanía*—"Yes to Romania") and taking a great interest in science, especially physics. Though Freud, Surrealism, and Europe were fundamental to him, they were "the world of yesterday," which is the title of the memoir of Stefan Zweig, the man who introduced Dalí to Freud. America, the commercial urge, science, and religion constituted, on the other hand, various facets of a future that could be effected on a single plane. Thus, in the lecture entitled "Why I Was Sacrilegious, Why I Am a Mystic," which he delivered at the Ateneo of Barcelona in 1950, Dalí stated: "The process of the specific sciences of these times immerses young people today in metaphysics. . . . The unity of Einstein's universe sensationally reactivates the sublime mysticism of the Bible. In 1950, for the first time in history, modern physics shows us God." As he liked to say, there was no difference between science and metaphysics; they were actually the same thing. And in metaphysics, that is, in science, what this supposedly fervent-Catholic agnostic set out to do was justify faith in God and, hence, the possibility of eternal life.

If initially he planned to achieve eternal life by freezing his body (as Walt Disney, whom he admired greatly, had done) until a point in the future when science had defeated death, he soon sought, and found, more plausible reasons for hope. He was fascinated by *The Double Helix*, the famous book in which James Watson relates the process that led him, along with Francis Crick, to discover the structure of DNA. In Dalí's personal library (which is now at the Fundació Gala-Salvador Dalí in Figueres, which also houses the hitherto unpublished text that follows), he had a copy of that book, which was underlined profusely and full of unintelligible notes in the margins. Dalí emphatically marked the ironic sentence from the article that the two researchers had written for *Nature* magazine, where they suggested the breadth of their discovery: "It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material." Dalí was obsessed with DNA: "Deoxyribonucleic acid is nothing other than the central component of life and of the persistence of memory" (Dalí's soft clocks at MoMA, etc.). "The latest discoveries in genetics show us that the laws of God are the laws of inheritance contained in deoxyribonucleic acid." To the satisfaction of Dalí's enormous ego, when Watson came to visit the artist at his hotel in New York, he announced his presence by saying, "The second most important man in the world wants to meet the most important man in the world." And when the mathematician René Thom, author of catastrophe theory—which, according to Dalí, was "the most beautiful aesthetic theory in the world"—confirmed the artist's "paranoid-critical" conjecture about the geologic importance of the space between Salses and Narbonne (specifically of Perpignan, and more specifically of the Perpignan station) to continental drift, Dalí almost broke into tears. His intellectual curiosity was stimulated by the magazine *Scientific American*, to which he subscribed. It was also a constant source of ideas and images for his canvases. Through *Scientific American*, he first learned about Heisenberg's theories: "After Heisenberg and his uncertainty principle, we know that there are charmed atoms, insofar as charm is a property of certain atoms."

The text reproduced below, probably the only one of Dalí's writings at the Fundació Gala-Salvador Dalí that is still unpublished, contains some anecdotes about Freud and Zweig that Dalí recounts elsewhere. But I don't think

he had ever told the story of his last encounter with Zweig in New York and the nature of the conversation they had. Indeed, one of the most interesting things about it is that it gives us a glimpse of the admirable humanist who wrote *The World of Yesterday*.

Ignacio Vidal-Folch (b. 1956) is a journalist and author living in Barcelona.

Salvador Dali, *Espagne*, 1938
Oil on canvas / Öl auf Leinwand
91.8 × 60.2 cm

Salvador Dalí, *Le grand paranoïaque*, 1936
Oil on canvas / Öl auf Leinwand
62 × 62 cm

Einführung

Ignacio Vidal-Folch

Tod, Unsterblichkeit und Dalí

Die Faszination des 19. Jahrhunderts für die Fortschritte der Wissenschaft und, nach der Entdeckung des Wunder wirkenden Penicillins, insbesondere ihres freundlichsten Gesichts, der Medizin, hat im Laufe des 20. Jahrhunderts stetig zugenommen, wohingegen das Interesse der Massen für die Lehren der Literatur und des Humanismus sank wie ein stolzer Atlantikdampfer, der den großen Eisberg der Enttäuschung rammte. Auch mich selbst, der ich nichts anderes mache, als zu lesen und zu schreiben, haben die Forschungen von Aubrey de Gray, einem Gerontologen aus Cambridge mit einem höchst pittoresken Bart, stärker beeindruckt als jeder Roman. Er und andere Gelehrte sagen voraus, dass wir schon bald den Tod werden hinauszögern und letztlich ganz überwinden können, indem wir die Zellalterung aufhalten. Denn in den Zellen, so Gray, ist nicht festgeschrieben, dass sie zwangsläufig einem Veränderungsprozess unterliegen müssen. Andere, wie der Physiker Kevin O'Regan, behaupten, dass der Mensch in ein paar hundert Jahren in der Lage sein wird, einem Computer ein Bewusstsein zu geben. Dabei muss der Computer kein kalter, metallischer Roboter sein, sondern vielleicht ein organisches, des Fühlens mächtiges Ding, womöglich im Zusammenhang mit dem Klonen. Der Informatiker und Erfinder Ray Kurzweil konserviert DNA und andere Besitztümer seines Vaters Cedric in der Hoffnung, dass er eines Tages eine virtuelle Person erschaffen kann, die diesem sehr ähnlich ist.

Soweit die guten Nachrichten. Und jetzt die schlechten: Höchstwahrscheinlich werden Sie und ich und sämtliche Menschen, die wir kennen und die uns etwas bedeuten, nicht in den Genuss dieser Fortschritte kommen. Die Entwicklung der Unsterblichkeit braucht noch viele Jahre, weitere Investitionen, weitere Forschung. Obwohl, wenn man es recht bedenkt, ist das vielleicht gar keine schlechte Nachricht, denn die Unsterblichkeit kann auch ein Unglück sein, wie bei den Struldbrugs in der Erzählung von Swift, die man bei

ihrer Geburt an dem roten Fleck über der linken Augenbraue erkennt und die sich nach einigen hundert Lebensjahren als »der Freundschaft unfähig und für jede Neigung erstorben« erweisen und den traurigsten Anblick darstellen, dessen Gulliver in seinem ganzen Leben teilhaftig wird. Auch in Borges' Erzählung »Der Unsterbliche« verwandeln sich jene, die vom Tod verschont bleiben, im Laufe der Jahrhunderte zu apathischen, gedächtnislosen Troglodyten. Der leibhaftige Homer, einer von ihnen, hat vergessen, dass er die *Odyssee* geschrieben hat, und führt sich wie ein Affe auf.

Canetti schreibt in seinen Aufzeichnungen vom »ganz konkreten und ernsthaften, dem eingestandenen Ziel meines Lebens, [der] Erlangung der Unsterblichkeit für die Menschen«. Ach! Hätte er noch ein paar Jahrzehnte durchgehalten, vielleicht hätte er gesehen, wie dieser Wunsch in Erfüllung geht. Wer weiß? Es kann auch sein, dass die Welt untergeht, bevor wir die Unsterblichkeit erreichen. Stephen Hawking wiederholte kürzlich seine These, dass die Menschheit nur überleben könne, wenn sie in der Lage sei, innerhalb recht kurzer Zeit andere Planeten außerhalb des Sonnensystems zu besiedeln, etwas, das der große Physiker für durchaus machbar und sogar wahrscheinlich hält. Er ist da optimistisch. Andere sind skeptischer, wie etwa die Schriftsteller Philip Roth und Milan Kundera:

> Roth: Glauben Sie, dass die Welt bald untergeht?
> Kundera: Kommt ganz darauf an, was Sie unter »bald« verstehen.
> R: Morgen oder übermorgen.
> K: Die Vorstellung, dass die Menschheit auf die Katastrophe zusteuert, ist schon sehr alt.
> R: Dann muss man sich ja keine Sorgen machen.
> K: Im Gegenteil! Wenn uns diese Vorstellung so lange begleitet, dann wird das schon seinen Grund haben.

Die Wahrheit ist, dass wir nicht genau wissen, ob uns hinter der nächsten Ecke ein Geburtstagskuchen mit tausend Kerzen oder die Apokalypse erwartet. Wir wissen nicht einmal, was wünschenswerter wäre. Kürzlich wurde der hundertste Geburtstag von Cioran begangen. Der beste Freund dieses Pessimisten mit dem großartigen Sinn für Humor war ein weiterer Exilrumäne in Paris, Eugène Ionesco, der wegen seiner Verdienste um das Theater in die Académie française aufgenommen werden sollte. Cioran versuchte ihn davon zu überzeugen, die Auszeichnung nicht anzunehmen, denn Akademiemitglied zu sein, bedeute eine Degradierung und Banalisierung. Besser, man bleibe in der Dunkelheit der Anonymität und ein Außenseiter. Der Rang, der einem Schriftsteller am besten zu Gesicht stehe, sei der des Taugenichts. Außerdem sei die Gala-Uniform lächerlich. Trotz dieser soliden Argumente beharrte Ionesco darauf, der Académie beizutreten. Cioran drang immer weiter in ihn, es nicht zu tun, und gab erst klein bei, als er merkte, dass sein Freund allmählich ärgerlich wurde.

Als er schließlich in die Académie aufgenommen wurde, sagte Ionesco zu ihm: »Geschafft. Ich bin gerettet. Jetzt bin ich unsterblich [denn so werden die Mitglieder der Académie genannt: *immortels*]. Und zwar für immer!« Doch Cioran musste ihn enttäuschen: »Nein, manchmal werden sie wieder hinausgeworfen. Denk an Pétain, Maurras, Daudet.« Mit einem Lächeln antwortete Ionesco: »Dann gibt es also noch Hoffnung?«

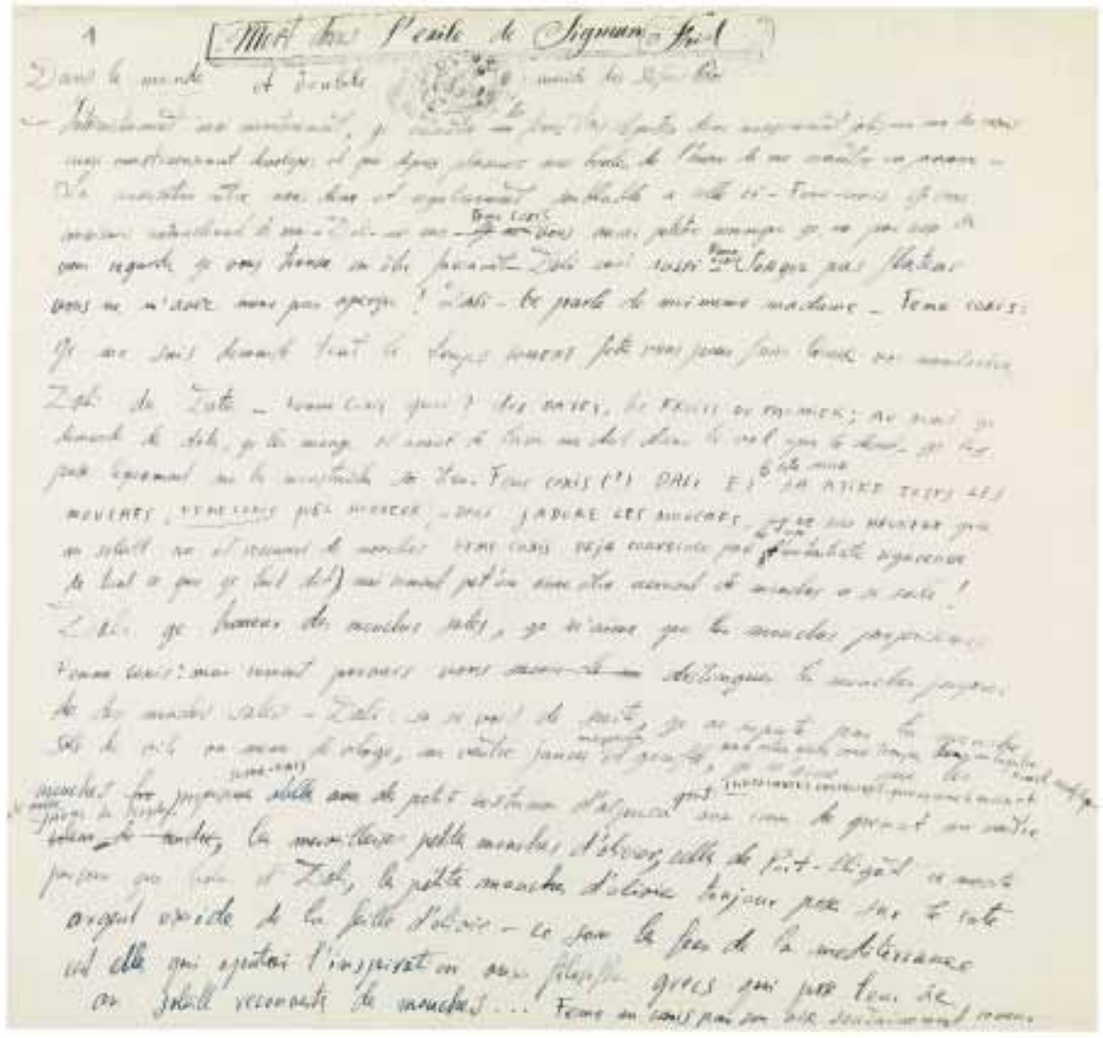
Salvador Dalí war ein hochintelligenter, enorm kultivierter Mann mit überbordender Fantasie. Ein Original. Ganz und gar nicht originell war indes seine Angst vor dem Tod, die er mit allen Menschen teilte, sobald sie ein bestimmtes Alter erreichen. Bei Dalí traten die Angst vor dem Tod und sein Interesse an der Unsterblichkeit aufgrund der besonderen Umstände seiner Geburt (als Bruder eines neun Monate vor seiner Geburt mit noch nicht zwei Jahren verstorbenen Kindes, das wie er Salvador hieß) schon früh zutage, doch nach den Erfahrungen des Spanischen Bürgerkriegs und des Zweiten Weltkriegs wurden sie zu einer alles beherrschenden Obsession, die sein intellektuelles Leben in zwei klar differenzierte Teile spaltete: Der erste ist bestimmt von der Ergründung der Psyche durch Sigmund Freud und von der Ästhetik des Surrealismus. Und im zweiten, nach seinem Exil in Amerika, setzt er der Angst vor dem Tod eine typische und topische Antwort entgegen, indem er sich zum Katholizismus bekehrt (»Ich bin katholisch, apostolisch, römisch und rumänisch«, erklärte er hochtrabend anlässlich der Publikation von *Sí* in Bukarest, einem Meilenstein, dessen Titel er allerdings später in das passendere, zynischere und witzigere *Sí a Rumanía* – »Ja zu Rumänien« abänderte) und ein wachsendes Interesse für die Wissenschaft, insbesondere die Physik, entwickelt. Freud, der Surrealismus und Europa, für ihn von fundamentaler Bedeutung, verkörperten die »Welt von Gestern«, so der Titel der Lebenserinnerungen Stefan Zweigs, der es auch war, der Dalí mit Freud bekannt machte. Und Amerika, die wirtschaftliche Habgier, die Wissenschaft und die Religion waren für ihn unterschiedliche Facetten der Zukunft und auf einer Ebene austauschbar. So sagte er bei einem Vortrag, den er 1950 unter dem Titel »Warum ich ein Gotteslästerer war, warum ich ein Mystiker bin« im Ateneo von Barcelona hielt: »Der Fortschritt der Wissenschaften unserer Zeit treibt den jungen Menschen von heute in die Metaphysik […]. Die Einheit des Einstein'schen Universums macht auf aufsehenerregende Weise die sublime Mystik der Bibel wieder aktuell. 1950 zeigt uns die moderne Physik zum ersten Mal in der Geschichte das Antlitz Gottes.« Weil er Wiederholungen mochte, war die Wissenschaft nichts anderes als die Metaphysik, sie waren ein und dasselbe. Und durch die Metaphysik, das heißt, die Wissenschaft, wollte dieser Agnostiker, der für sich den Anspruch erhob, ein glühender Katholik zu sein, den Glauben an Gott und folglich an die Möglichkeit ewigen Lebens rechtfertigen.

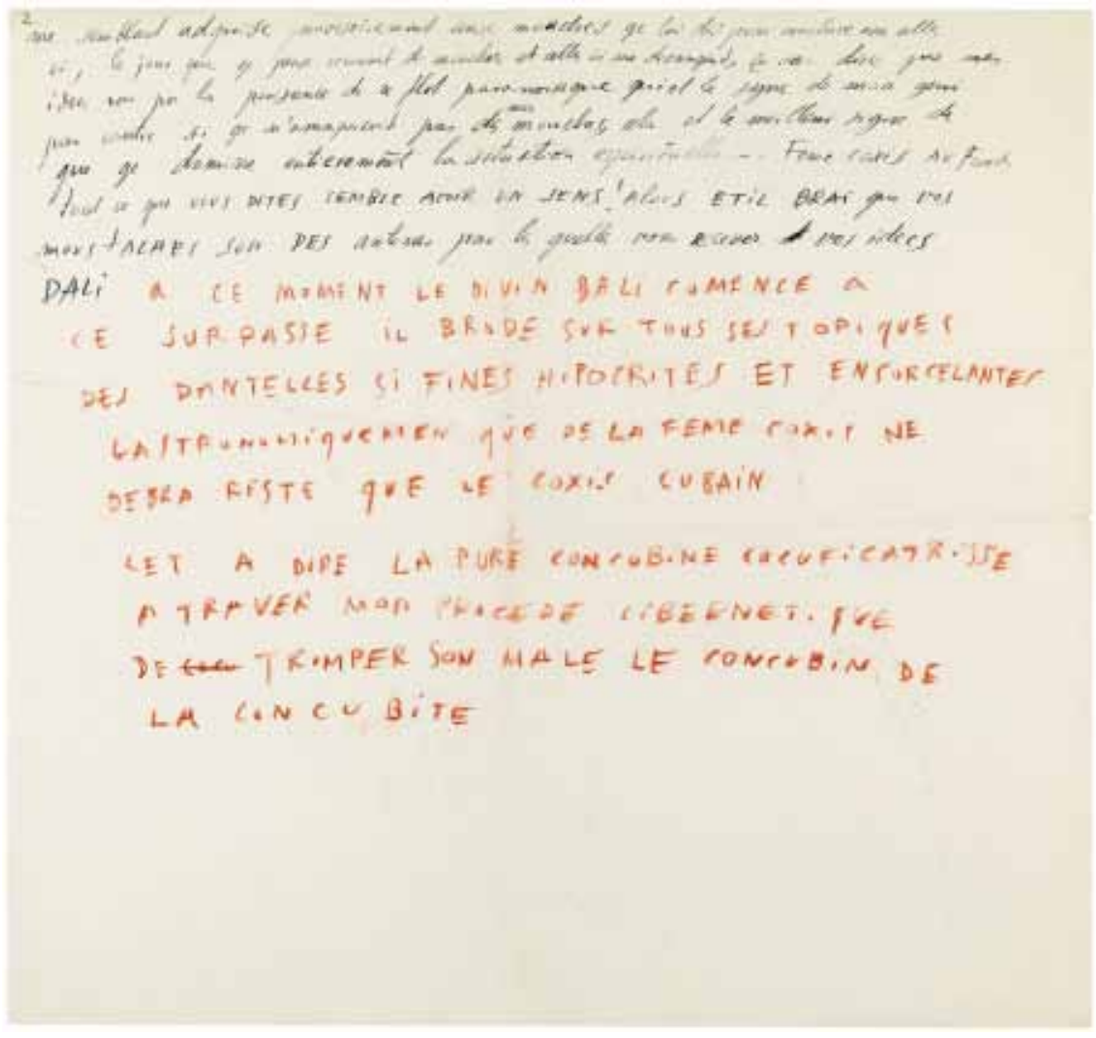
Hatte er zunächst vor, seinen Leichnam durch Einfrieren zu konservieren (wie der von ihm bewunderte Walt Disney), bis die Wissenschaft in der Zukunft den Tod besiegt haben würde, so suchte und fand er bald plausiblere Gründe zur Hoffnung. Die Lektüre von James Watsons berühmtem Buch *Die Doppelhelix*, in dem der Wissenschaftler schildert, wie er und Francis Crick die DNA-Struktur entdeckten, faszinierte ihn. In seiner persönlichen Bibliothek (die in der Fundació Gala-Salvador Dalí in Figueres aufbewahrt wird, von wo auch der unten folgende, bislang unveröffentlichte Text stammt) befand sich ein Exemplar dieses Buchs mit zahlreichen Unterstreichungen und unleserlichen Randkommentaren. Dick umrandet ist auch der ironische Satz in einem Aufsatz für die Zeitschrift *Nature*, mit dem die beiden Forscher die Reichweite ihrer Entdeckung absteckten: »Es ist unserer Aufmerksamkeit nicht entgangen, daß die spezifische Paarbildung, die wir hier voraussetzen, sogleich an einen möglichen Kopiermechanismus für das genetische Material denken läßt.« Dalí war besessen von der DNA: »Die Desoxyribonukleinsäure ist nichts anderes als der zentrale Faktor des Lebens und des Weiterbestehens der Erinnerung« (Dalís zerfließende Uhren im MoMA usw.). »Die jüngsten Entdeckungen der Genetik zeigen uns, dass die Gesetze Gottes nichts anderes sind als die in der Desoxyribonukleinsäure enthaltenen Informationen.« Es schmeichelte seinem Narzissmus außerordentlich, als Watson ihn in seinem New Yorker Hotel besuchte und sich ankündigen ließ als »der zweitwichtigste Mann der Welt, der den wichtigsten Mann der Welt kennenlernen möchte.« Und als der

Mathematiker René Thom, Autor der Katastrophentheorie, Dalí zufolge »die ästhetisch schönste Theorie der Welt«, seine »paranoid-kritische« Vermutung von der geologischen Bedeutung des Gebiets zwischen Salses und Narbonne (und insbesondere Perpignans, noch genauer des Bahnhofs von Perpignan) bei der Kontinentaldrift bestätigte, begann er fast zu weinen. Seine intellektuelle Neugier fand ständige Anregungen, Ideen und Bilder für seine Gemälde bei der Lektüre der Zeitschrift *Scientific American*, die er regelmäßig bezog und die ihn mit den Theorien Heisenbergs bekannt machte: »Nach Heisenberg und seinem Prinzip der Unschärfe wissen wir, dass es begeisterte Atome gibt, sofern Begeisterung eine Eigenschaft bestimmter Atome ist.«

Der folgende Text, der vielleicht einzige bislang unveröffentlichte unter den zahlreichen Aufzeichnungen Dalís, die in der Fundació Gala-Salvador Dalí verwahrt werden, wiederholt in einigen Passagen Anekdoten, die dieser bereits an anderer Stelle über Freud und Zweig erzählte, aber ich glaube, dass er nie von der letzten Begegnung mit Zweig in New York und dem Inhalt ihres Gesprächs berichtet hat. Und das liegt nicht daran, dass sie von geringerem Interesse wäre, spiegelt sie doch einen Moment im Leben dieses für seine Überzeugungen so schätzenswerten Menschenfreundes wider, des Autors der *Welt von Gestern*.

Der Journalist und Autor Ignacio Vidal-Folch (geb. 1956) lebt in Barcelona.





Salvador Dalí, *Mort dans l'exile de Sigmund Froid (Interview avec la femme cocyx)*, undated manuscript / undatiertes Manuskript

Si déjà [illegible] pour [illegible] mantle à un ecclésiastique de Bourgogne
et le même se passe si on met la manche il faut la tenir avec un cerceau
alors elle est toute autour, je me dis à moi, et il y a pour à faire avec
ce "accessoire" j'aimais au but — D'ailleurs l'ecclésiastique de Bourgogne
a dessus de la guipure et que le dessus qui manque dans [illegible] peinture qu'on
a un tableau de El Greco — [illegible] El Greco et l'ecclésiastique de Bourgogne
Ses deux choses qui me [illegible] point de vue gastronomique de son [illegible] moins semblant que me gênes à cette
[illegible] pour avoir le mangé parmi de ces de perfections et je dis
pourtant — Mais l'ecclésiastique de Bourgogne de El Greco ne perdra rien pour attendre
par contre il [illegible] et mais ils [illegible] [illegible] à la Casa Miranda, [illegible] à Tolède je fais
[illegible] [illegible] [illegible] [

Je n'ai pu répondre plus tôt à votre gentille lettre, parce que j'attendais de savoir si Stefan Zweig a bien fait de venir passer quelques jours à Vienne et à Berlin. Je n'aimais pas le voir partir dans cette période de tension et de crise, et je me réjouissais de le savoir près de moi. Stefan Zweig est un homme d'une sensibilité extrême, et il a besoin de beaucoup d'affection. Il a été très touché par la lettre de Freud, et il a répondu à celle-ci avec une chaleur et une émotion qui m'ont bouleversé. Il a été très heureux de pouvoir parler de Freud avec quelqu'un qui l'a connu et aimé, et il a été très content de pouvoir lui montrer mon portrait de Freud. Il a trouvé que j'avais bien rendu l'expression de bonté et de sagesse qu'il avait toujours remarquée chez Freud. Il a été très touché par votre lettre, et il a été très heureux de pouvoir parler de Freud avec quelqu'un qui l'a connu et aimé, et il a été très content de pouvoir lui montrer mon portrait de Freud. Il a trouvé que j'avais bien rendu l'expression de bonté et de sagesse qu'il avait toujours remarquée chez Freud. Il a été très touché par votre lettre, et il a été très heureux de pouvoir parler de Freud avec quelqu'un qui l'a connu et aimé, et il a été très content de pouvoir lui montrer mon portrait de Freud. Il a trouvé que j'avais bien rendu l'expression de bonté et de sagesse qu'il avait toujours remarquée chez Freud.

Cela me fait penser que j'ai encore deux portraits de Freud à faire, l'un de profil, l'autre de face. Je ne sais pas encore quand je pourrai les faire, car je suis très occupé en ce moment. Je viens de terminer le portrait d'une jeune fille, et je vais commencer celui d'un jeune homme. Je ne sais pas encore quand je pourrai faire les portraits de Freud. Je ne sais pas encore quand je pourrai faire les portraits de Freud. Je ne sais pas encore quand je pourrai faire les portraits de Freud.

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How a Tadpole Becomes a Frog

The dramatic changes of the process are stimulated by thyroid hormone. The level of hormone is regulated by a feedback system involving the hypothalamus of the brain and the pituitary gland

—by William Etkin

Of all the mysteries of life one of the most intriguing is that of metamorphosis. The transformation of a caterpillar into a butterfly or of a tadpole into a frog has long fascinated naturalists, and it is currently yielding important information on various phenomena from evolutionary adaptation to the differentiation and specialization of cells. A recent article in *Scientific American* discussed chemical aspects of the transformation process [see "The Chemistry of Amphibian Metamorphosis," by Earl Frieden; November, 1963]. The present article is an account of what has been learned about the hormonal mechanism that activates the chemical changes that transform a tadpole into a frog.

The frog starts life as a small swimming organism capable only of a fish-like mode of life in the water. It breathes by means of gills, feeds on water plants and pond debris and is equipped with swimming apparatus in the form of a long tail. The duration of the tadpole stage varies greatly: in some of the smaller species it lasts only two or three weeks and the tadpole grows to no more than an inch in length; in the case of the bullfrog the animal remains a tadpole for three years and reaches a length of up to nine inches.

The first sign of change comes when buds near the rear end of the animal's trunk begin to develop into limbs: the jumping legs of the frog. The development of these legs, accompanied by other, less conspicuous changes, takes two to six weeks, depending on the size of the tadpole. In this phase, called prometamorphosis, the animal remains a water-dweller. When the hind legs have grown to about the size of the animal's torso, the tadpole abruptly enters the stage of rapid changes called the metamorphic climax. Forelegs suddenly erupt through small openings in the covering of the gills; the mouth widens and develops powerful jaws and a large tongue; the lungs and skin complete their transformation; nostrils and a mechanism for pumping air develop, and the gills and tail are resorbed by a process of self-digestion and thus disappear. Before the week of climax is over the animal emerges to a new life on land.

The process takes place in an orderly fashion and with exquisite timing, each new development fitting into a complex and perfectly coordinated pattern. The resorption of the swimming tail does not begin until the jumping legs have nearly completed their growth; the nostrils and air-pumping mechanism develop before the gills are resorbed. Clearly the metamorphic process as a whole must be organized by some master mechanism within the animal's regulatory system. The search for the nature of this mechanism has been pursued for more than half a century.

Our story begins with a discovery in 1912 by the German biologist Friedrich Gudernatsch. He fed extracts from various body organs to tadpoles and found that an extract from the thyroid gland had a striking effect. Within a week the treated tadpoles showed some of the typical signs of metamorphosis: rapid growth of legs, widening of the mouth, resorption of the tail. Biochemists eventually identified the thyroid substances that produced these changes as the hormone thyroxine and its three-iodine variant triiodothyronine.

The discovery that thyroid hormones played a critical part in producing metamorphosis raised more questions than it answered. How could this single stimulus generate the entire orderly sequence of metamorphic change, affecting so many body tissues in so many different ways? This question particularly intrigued me when I first became interested in the investigation of metamorphosis more than 30 years ago.

One point seemed obvious: In all likelihood the progress of metamorphosis was connected with increasing activity of the thyroid. Microscopic examination of the gland supported this idea. In tadpoles that had not yet begun to metamorphose, the thyroid was small and its cells appeared inactive. During premetamorphosis, however, the gland grew rapidly, and by the time the animal reached metamorphic climax the thyroid was large and apparently extremely active. Further confirmation of a connection between the level of thyroid hormone and the metamorphic process was provided by experiments in which tadpoles were deprived of their thyroids by surgery and were then given various doses of thyroxine.

Exposing the animals to a low dose of the hormone produced the characteristic development of the premetamorphic stage, marked by rapid growth of the hind legs. If the hormone concentration was maintained at this low level, the later stages of metamorphosis developed only with extreme slowness. High levels of hormone, on the other hand, produced a normal rate of change for such climax events as tail resorption but did not allow enough time for other changes, such as hind-leg growth. The resulting animal was not viable; it could live neither in water nor on land. I found that to induce the normal speed and timing of metamorphosis the hormone concentration had to be started at a low level and then be increased at least twentyfold as the metamorphic process advanced to the final stage [*see illustrations on next page*].

In our laboratory at the Albert Einstein College of Medicine in New York we have developed a standard procedure for transforming immature tadpoles into frogs. We provide the hormone through the water medium in which the animals swim. We start with a concentration of one to three parts of thyroxine to a billion parts of water. When the growth of the tadpoles' hind legs, signaling prometamorphosis, has reached about a third of the normal length, we raise the thyroxine concentration to about 10 parts per billion. Finally, when the forelegs emerge, marking the start of metamorphic climax, we increase the thyroxine concentration to between 200 and 1,000 parts per billion. At this concentration of hormone the final events of metamorphosis proceed at their normal pace.

The regulating agent for metamorphosis was thus shown to be the activity of the thyroid gland. But plainly this was not the ultimate control. What regulated the changing rate of activity of the thyroid? Earlier research had already suggested an answer. This regulation must lie in the pituitary gland, which holds the key to stimulation of the thyroid.

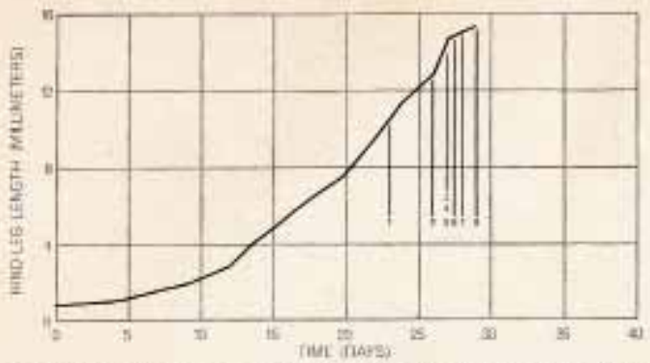
Bennet M. Allen, then working at the University of Kansas, and Philip E. Smith, then at the University of California at Berkeley, had found that tadpoles whose pituitary glands had been removed failed to metamorphose into frogs. (Smith's experiments on tadpoles were the beginning of his classic investigations of the pituitary, which helped to establish the modern science of endocrinology by showing that the pituitary is the master gland regulating many other endocrine organs.) By the time I began my work on metamorphosis it was known that the thyroid's activity is controlled by a pituitary hormone called thyrotropin or thyroid-stimulating hormone (TSH).

What, in turn, regulates the output of TSH by the pituitary? It began to appear that tracking down the control of metamorphosis to its ultimate source might be an arduous task.

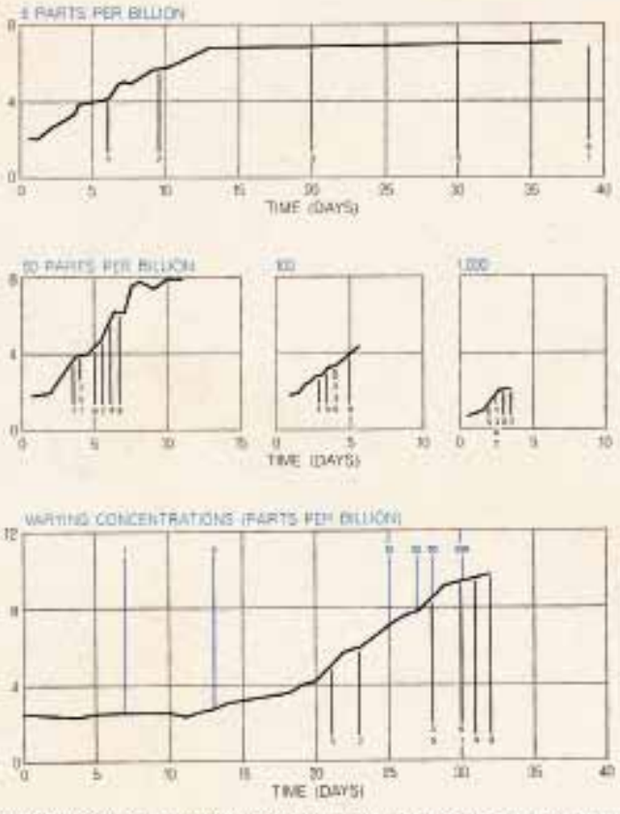
I considered three possible agencies that might stimulate the pituitary's secretion of TSH. The stimulus might come from another endocrine gland, from the brain (to which the pituitary is attached) or from some mechanism

GRASS FROG (*Rana pipiens*) changes from an aquatic larval form into a terrestrial animal during metamorphosis. The tadpole is shown soon after hatching (*left*) and when it is full-grown, just before metamorphosis (*second from left*). Some 20 days later, late in prometamorphosis, the hind legs are largely developed (*third from left*). The completely transformed frog is shown at the right.

Notes by Salvador Dalí in an article published in the magazine *Scientific American*, vol. 214, no. 5, May 1966 /
Notizen von Salvador Dalí in einem Artikel aus dem Magazin *Scientific American*, Vol. 214, Nr. 5, Mai 1966



SEQUENCE OF EVENTS in the normal metamorphosis of the Western wood frog (*Rana cantabrigensis*) is plotted with hind-leg length. The events are the reduction (*1*) and complete resorption (*2*) of the anal canal piece, the appearance of a "skin window" for a foreleg (*3*), the emergence of a foreleg (*4*), marked reduction of lips and loss of horny teeth (*5*), loss of horny beaks (*6*) and the beginning (*7*) and completion (*8*) of tailfin resorption.



HORMONE CONCENTRATION governs the rate and sequence of changes in induced metamorphosis. At five parts per billion parts of water (*top*) the changes occur slowly. At high concentrations (*middle*) the changes occur out of sequence and before the legs grow. A normal pattern is approximated (*bottom*) when the hormone concentration is varied.

within the pituitary itself that began to operate when it reached a certain stage of development. To test these hypotheses I removed the tadpole's pituitary from its attachment to the brain and transplanted it to various other sites in the body, performing the operation during the gland's early development in the embryo. The results of the transplantation experiments were tantalizingly ambiguous. Most of the tadpoles eventually showed some leg growth, but their progress toward metamorphosis was long delayed and far slower than normal. Some of the animals simply went on growing as tadpoles without showing any sign of metamorphosis.

The failure of metamorphosis to develop normally indicated that the pituitary's function of promoting metamorphosis was not regulated by hormones from another gland, because such hormones should reach the pituitary by way of the bloodstream regardless of where the pituitary might be located in the body. On the other hand, the fact that many of the tadpoles showed signs of the beginning of metamorphosis, even though the pituitary was transplanted from its normal site on the underside of the brain, suggested that the metamorphic process did not depend on messages from the brain. (Actually, for reasons that will become clear, this interpretation was not valid.)

It seemed, then, that metamorphosis must be controlled by a developmental clock within the pituitary that timed the pattern of the gland's activity. The abnormally slow development of metamorphic changes when the pituitary was transplanted might therefore be due to some transplantation setback that slowed the clock.

Our studies of metamorphosis were interrupted (like a great deal of other work in biology) by World War II. By the time we resumed the investigation in the 1950's various new discoveries in endocrinology and studies of the functioning of the nervous system cast a totally new light on the questions we had been asking. A number of items of information were suddenly found to fit together, like the pieces of a jigsaw puzzle, to form a more meaningful picture of the mechanism of control of metamorphosis.

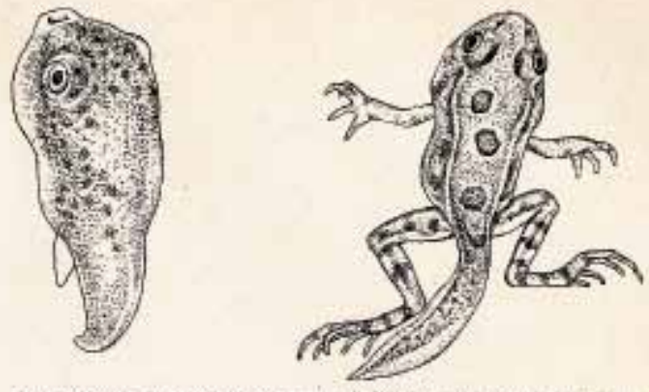
Tomomasa Uyematsu of the University of Kyoto had performed an experiment somewhat similar to ours. Instead of transplanting the pituitary from its attachment to the brain, he removed the part of the hypothalamus in the brain to which the pituitary is attached. He found that after this operation the metamorphosis of a toad tadpole could proceed through the early stages, but that the process stopped abruptly when it arrived at the climax stage. We repeated his experiments on frog tadpoles and also explored again the effects of transplantation of the pituitary; in both cases we found that the process of metamorphosis did indeed come to a halt at the beginning of climax.

Uyematsu had supposed that the metamorphic failure was due to degeneration of the pituitary, caused by its disconnection from the brain. In our experiments, however, we found that the pituitary was not impaired and was functional with respect to other hormones it produces. We therefore concluded that the failure of metamorphosis to proceed through climax was simply due to the lack of connection between the pituitary and the brain. This idea was confirmed in experiments on the common spotted salamander: when a barrier was interposed between the brain and the pituitary, the larva of that animal did not metamorphose.

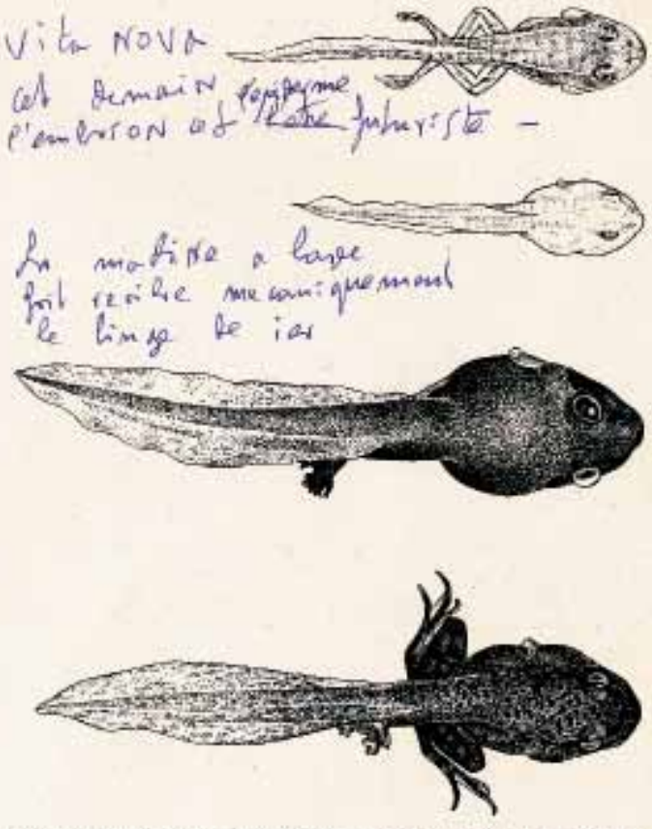
It was now apparent that the brain does, after all, play a controlling role in metamorphosis. From the results of our earlier experiments we had judged that the brain was not involved, because disconnection of the pituitary from the brain did not prevent the development of premetamorphic changes. In retrospect we could see that we had sacrificed those animals (for morphological examination) too soon; if we had kept them for a longer period, we would have observed that the animals could not complete the climax phase of their transformation. Evidently premetamorphosis, requiring only a low level of stimulation by thyroid hormone, could proceed without direct stimulation from the brain, but to induce the metamorphic climax the brain had to stimulate the pituitary to increase its secretion of TSH to a high level and thus step up the thyroid's activity.

How did the brain transmit the stimulus to the pituitary? The answer to this question was surprising indeed. It emerged from two entirely separate discoveries that had intrigued and mystified anatomists for many years.

The first of these discoveries, developed by Ernst A. Scharrer and his wife Berta, was that certain nerve cells manufacture hormone-like substances ("neurosecretions") that travel along the nerve-cell fibers and are released at their terminals. The concept that nerve



HIGH CONCENTRATION of thyroxine causes the tail to be resorbed before the legs have grown and the mouth parts to change in uncoordinated fashion (*left*). Varying the thyroxine concentration from a low to a high level produces more normal metamorphosis (*right*).



EFFECT OF PITUITARY on metamorphosis was studied by removing the gland and by transplanting it. A normally metamorphosing tadpole is shown at the top. An animal without a pituitary fails to metamorphose (*second from top*). If the pituitary is transplanted to the tail (*third and fourth from top*), metamorphosis is delayed and varies in different animals.

100 Notes – 100 Thoughts / 100 Notizen – 100 Gedanken

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