ACADEMIA ROMÂNĂ
Revue Roumaine de Chimie
http://web.icf.ro/rrch/

Rev. Roum. Chim.,
2016, *61*(8-9), 637-645

Dedicated to Professor Claude Nicolau
on the occasion of his 80th anniversary

TULIPOMANIA – THE FIRST FINANCIAL CRISIS BY VIRUSES

Karin MOELLING*

Institute of Medical Microbiology, University of Zurich, Gloriastr 32, CH-8006 Zurich, Switzerland, Max Planck Institute for Molecular Genetics, Ihnestr 63-73, D-14195 Berlin

Received December 21, 2015

Viruses are known as causes of diseases. Yet many viruses do not cause harm, some may even lead to beauty. There is the family of viruses, the Tulip Breaking Virus, which breaks the color of tulip petals. They were the desire of rich merchands in the 17th century who wanted to own these rare tulips. The demand exceeded the supply and caused the first financial crisis known, the tulipomania. It was a consequence of a virus, which did never allow pattern predictions due to its infection mechanism and led to speculations and hope for financial gains. The mechanism for financial crises today is still the same, unpredictability, gambling and desire. The molecular mechanism of the tulip breaking virus is still rather unknown. It may be caused by "gene silencing", *i.e.* inactivation of color gene expression by a virus and/or environmental conditions.

INTRODUCTION

Art Basel

In May of 2015 I visited the "Art Basel" one of the biggest Art fairs, and stopped in front of a picture with striped tulips. A striped tulip was reminescent of a Dutch painting from the 17th century but it was strangely modified, contours were not sharp, smears from top to bottom indicated that the artist, Gordon Cheng from the UK had alienated the original. The galerist came to explain to me that a virus had been used to modify the Dutch original. A virus? I was thinking of a virus which caused the stripes in the tulips. No, this is not what the galerist meant, a "glitchy" virus he was talking about, a commercial computer program applicable to photographs availabe in the photoshop computer program. A flower virus he had never heard about. We were talking about two different viruses. I mentioned the famous artist Maria Sibylla Merian, also from Basel, who painted striped tulips more than 350 years ago and became a celebrity until today for her etchings - the galerist did not know her name. He had heard of Rembrandt - even though not of this famous picture of "The Anatomy Lesson of Dr. Tulp", a group of men, the only one with a hat is Dr. Tulp, who acquired this name to make his veneration and enthusiasm of the beautiful tulips public. He named his home Dr. Tulp`s home.

The galerist told me that he would have a vernissage in the Fall about "Striped Tulips" in his gallery in London and invited me on the spot to come and talk there and explain some of these

* Corresponding author: moelling@molgen.mpg.de, +49 172 3274306

details. I went there. The exhibition was in honor of the artist Gordon Cheng, a British artist of Chinese origin, about 40 years of age. He explained to me the brownish background behind a tulip, which was full of rows of tiny numbers - a copy of the page from a newspaper, Finacial Times, with the stockmarket information from the day of the financial crisis, breakdown of Lehman Brothers Investment Bank on September 15th, 2008. Now I own such a picture, two times viruses on a single picture for a virologist that was a "must-have", due to my "déformation professionelle".

Here come the two stories, one of Maria Sibylla Merian and her tulips and the other one about the tulipomania both caused by real viruses.

Maria Sibylla Merian - a tulip career

Maria Sibylla Merian is one of my heroes. She was not noticed or appreciated for almost centuries but with the beginning of the gender era, she received attention. Her picture was printed on one side of the German 500 DM note - which, however, many people never were lucky enough to see or even own. But perhaps many of them used the stamp in the pre-e-mail times, even though they may not have recognized who she was. At the age of 14 she became a "criminal" and almost had to go to prison having stolen striped tulips from her neighbor`s garden. She wanted to draw them and did hide them in a chamber under the roof of her father`s house. This was even topped by a later danger, when she was accused of witchery and almost ended up on a fire stake - because she was collecting strange animals, worms and caterpillars, considered as witchcraft attributes by her contemporaries.[1,2]

She was born in 1647 as the youngest child and only daughter of Matthäus Merian, the famous copper etching specialist who traveled through Europe and produced datailed and correct city profiles which he etched into copper and colored them. They decorate almost every single city hall now in memory of the ancient days. His sons continued with this business. About 2200 etchings of cities or landscapes were collected in a book, Topographia Germaniae. They are even today affordable as wall decorations, because they were "multiples", perhaps the first of their kind.

He had passed away when his daughter saw the beautiful tulips in the garden of a neighbor, who had even a guard to watch the precious tulips. They were worth a fortune then. As the neighbour`s daughter she was probably not assumed to be a potenial thief, so she succeeded in getting the tulips, not only one but a bunch of them, rather brutally ripped off from the garden. This is how it is reported. Perhaps she was in a hurry and knew that this was not right what she did. She disappeared under the roof of her home and stealthily drew the flowers.

The theft was discovered and she was supposed to be punished by her neighbor, a world-open Duke Ruitmer, whom she gave her pictures as an excuse. He was overwhelmed by their quality and beauty and instead of punishing the girl he insisted she should be educated as a painter and supported her. This is reported, whether it’s true or not remains open for debate. If she was 14 then, this must have been 1661 since she was born in 1647. The tulipomania was over by then. So all this may be a nice legend!

M. S. Merian resisted her brothers who did not much support her as a female and even more so she had to cope with her mother, who was appalled by a daughter who was filling little boxes in her kitchen with caterpillars and worms, because she was worried that such a daughter could never get married and supported by a husband. The mother finally succeeded in finding a husband for her daughter in spite of her strange passion. After her father`s death her mother married the painter Jacob Morell in 1650. He had a student, Andreas Graff, who married SM Merian. Morell (1614-1681) was himself a well respected painter for flowers decorated with shells and small little worms. However, the difference to MS Merian was, he drew what he thought fit to the painting while Merian studied Nature and combined three things: caterpillars, plants and butterflies.

Her marriage was not very happy but lasted for 20 years, she left but continued to support her husband. Merian manged to make her living by drawing flower crowns, table decorations, gave teaching lessons to other ladies, designed an instruction booklet for how to do the paintings, most of which were used so much that they tore and disappeared. She was by law not allowed to draw oil paintings being a woman.[1-3]

Her scientific discovery was the metamorphosis: out of the hungry caterpillars the most beautiful butterflies evolved. She discovered how to feed the caterpillars correctly, each of them

had other plant preferences. A jigsaw decorates the reverse side of the 500 DM note together with a worm and a butterfly. On the top right I noticed a strange little symbol, which looks to me like a virus, a hexagonal structure of, for me, unclear relevance. Perhaps it as a watercolor as protection against false 500 DM notes to make it more difficult to imitate. She ran around the fields in male dresses collecting animals and plants and stayed away on Sunday mornings from the obligatory church services. So she became the focus of irritation, suspicion and opposition. Too strange was her behavior. The painting women from the higher society stayed away, a priest condemned her collecting animals, and declared this as witchcraft. She was threatened to be burnt at stake as a witch. This was when the scientists of her time believed in gases, miasms, not food, not in metamorphosis. This was just unheard of, a triage of caterpillars, plants and butterflies.

Her brothers started worrying, activated sums of money to bribe her antagonists and to make them keep their mouth shut. She did not want to leave the city of Würzburg where they lived then, she had her own will. Finally she had to give in. With her aged mother and two daughters she traveled to Holland where one of her stepbrothers already had joined a sect of pietists with the name „Herrenhuter“ known today for pretty yellow Christmas stars. It was there a rather dogmatic and strict regime, which she did not like. The journey was endangered by some delays due to disease outbreaks, probably the Bubonic Plague, which still ravaged on local sites through Europe. She had two daughters, which she insisted to educate herself in spite of some opposition the sect. After her mother and brother passed away, she felt free. She had read a lot but did not paint much.

However, this not so fortunate colony offered an unexpected opportunity to her. It was founded by three sisters, who had a brother, a missionary in one of the Dutch colonies Surinam in South America. They owned a collection of the most beautiful butterflies - so she decided she wanted to go there and see them with her own eyes. This became possible through an adventurous order by the Mayor of the City of Amsterdam, who thought it would be very helpful to improve the somehow hostile atmosophere in the colony by sending her as a kind of ambassadeur. The Dutch merchants in Surinam had a bad reputation and were not well-liked at all, too much exploiting of the natives. A female scientist as delegate from Holland that would leave a very good impression. The Mayor knew well that this was life-threatening for her under the then usual conditions and had a bad conscience. Nevertheless she embarked with her older daughter on a trading kogge and sailed to Surinam. In a missionary station she collected and organized the exotic giganitc butterflies with their respective plants. She promised compensation to the natives if they supplied her with especially unusual samples. They cheated on her and fabricated artificial animals by combining different parts into single animals - which she later on noticed when her drawings went already to press in Holland and she could not prevent these chimaeras to be published. So they must be detectable in some of her volumes and may be in St. Petersburg, where most of her legacy ended up, the most famous was "Metamorphosis Insectorum Surinamensium" (1705). Peter the Great bought some of it and her son in law was appointed there as a botanist and took many of her drawings with him. It may be worth finding these false animals - but how would we know if Mrs Merian did not even find out about it as such an experienced specialist. So also this remains somewhere in between truth and legend.

Merian caught malaria fever and was not able to cope with the hot humid climate after some time and went home after two years (1699-1700). She wrote important letters to the Mayor and Senate of Amsterdam describing the situation of the natives. She distanced herself from the slavery trade and the exploiting behavior of her Dutch contemporaries. On the day of her death in 1717 she received the payments from Peter the Great from St. Petersburg, who had purchased some of her drawings. Her granddaughter Salome, whom Merian liked so much, got married in St. Peterburg to the mathematician Leonhard Euler (1707-1783) from Basel, whose famous family had emigated to St. Petersburg.[1,2]

Now in 2015 a research ship is named after her. It travels though the Baltic Sea, collecting marine samples, not all the way to Surinam - but still!

On my desk in Berlin I have a postcard from the Berlin Botanical Garden with nine most beautiful flower pictures with striped tulips by Maria Sibylla Merian. I do not know what I admire more, her art or her science! (Fig. 1)

Fig. 1 – (left to right) Tulip by Gordon Cheng, 2008, Tulip by MS Merian around 1665, Semper Augustus 1636, (bottom) 500 DM with jawsaw, caterpillar and butterfly. Portrait of SM Merian.

RESULTS

Tulipomania in Holland

The tulipomania culminated in Holland in the years 1636 and 1637. Tulips received their name from the head cover "turban" of the Turkish emperor, Suleiman the Magnificent. The head decoration looked a little different though, more like a closed tulip. Tulips came as prestigious objects and exotic samples for Turkey, but they may originally have come from Persia. More likely even is their origin in Siberia. During my presentation on the striped tulips in London a Dutch visitor indicated that she had seen tulip fields of red short tulips reaching all the way to the horizon as far as she could see. Perhaps they originate indeed from Siberia.

The tulips got from Turkey to the Court of Vienna with the Holy Roman Emperor Maximilian II, with the Ambassador Augier de Busbecque around 1560 and from there to Holland. On the Turkish glazed tiles the tulips have thin lengthy curved ends often located in the corners of the recangular terracotta plates and seem to be of different breeds. The Swiss Historian Conrad Gessner[4] (1516-1565), who was described as the Plinius Germaniae, mentioned for the first time the bulbs of the tulips together with the flower in a book "De Hortis Germanicus" around 1550. The Dutch tulips were planted by the botanist Carolus Clusius,[5] who became head of one of the first botanical gardens in Holland in 1593, called "Hortus Botanicus" in the city of Leiden. His tulip was selected for genome sequencing recently.

He already owned 500 different types of tulips! This number constantly increased. There is not a single other plant in the world with such a variety of different flowers. More than a thousand were known then (the explanation will follow below). This thrilled even the Calvinistic Dutch men. There were some rich merchants, who made a fortune with the East-Indian Colonies and now wanted to boast and show off with status symbols. The tulips were the right objects for this. The passion for tulips went very far, so far that the title of a famous paintiang by Rembrandt was called "The Anatomy Lesson of Dr Tulp", where the word "tulp" was the name of the Anatomist with a hat standing next to the sectioned lower arm of the body from 1632. He gave himself the name to demonstrate his passion for the tulips.

Then a mania about the tulips was in full swing.[6-9] Rembrandt received, for his most famous painting, the "Night`s Watch", 1600 Dutch Guilders, while the supertulip with the name Semper Agustus, of which apparently only 12 copies ever existed in total, made it on an auction to a price of 13 000 Dutch Guilders - these numbers are documented.

What was going on? Craziness, mania, wealth, boasting, gambling, mass hysteria, me-too effects, hazardous hopes, love, passion, vanitiy associations because of the short-living beauties, male symbolism represented by the upright attitude of the flowers.[7]

All of this happened at the same time, but most importantly: a virus was the cause!

The tulip bulbs were recovered from the soil after the blooming was over in May or June, were then kept dry indoors, then divided, the mother bulb was separated from the daughter bulbs. Then they were replanted in September. The demand was higher than the supply, so the price went up and the flowers were prepaid for in Fall before the blooms could be seen. It was unpredictable what the flowers would look like during the auctions in Spring, such uncertainty provoked gambling and increased the price. There were catalogues to choose from with flower patterns beforehand, with pictures one can look at till today. However, they were more the cause of anger because most of the tulips did not look like the predicted ones. The options paid for in Fall were not always fulfilled in Spring - some tulips turned out with no stripes at all and others had much nicer patterns than anticipated. The outcome was good or bad luck. There was something that turned tulips into gold. Some tulips, for no apparent reason, erupted from a solid color into a swirled, feathery bloom that was incredibly exotic and beautiful. Nobody knew why any single bulb did this, and no one was able to establish a pattern for the change. They also noticed that the most beautiful items were prone to die, that they did not appear healthy even the bulbs changed after a few blooming seasons, not immediately - which drove the prices even higher.[6-9]

In the taverns speculations were ongoing, downpayments had to be made, dinner invitations were expected and a fee had to be paid before the negotiations. There was a wild atmosphere throughout the nights. One of the participants took a mortgage on his restaurant to bet for tulips, which ruined him and coined the name of the tulip "Brasserie". There was fantasy required to find names for one thousand different tulips. Not an easy task. There was a "Rembrandt" tulip now designated as "Rem`s Sensation", and the almot black "Queen of the night", the hierarchy of military and governments had to supply names such as King, Viceking, "Viceroy", Admiral, Viceadmiral, General. One of them was "Absalon" with gold flames on chocolate brown background. Above all was Semper Augustus, a white tulip with blood-red flame-like stripes and inside with a blue shine. One thousand names were required, almost all referring to men, not ladies. The tulip was considered fierce, strong, male, upright, or straight. For the world of females the tulip represented elegance, thoughtfulness, vanitiy or wonder.

For some people the bulbs were even food, prepared as specialty with spices - however this did not last long, because they tasted rather bitter and may have even been toxic because of traces of alkaloid poisons. This increased gambling and tulips became lottery tickets.

Some people could not afford to buy tulips and therefore ordered some oil paintings with striped tulips as a replacement. A Curator at the Zurich Art Gallery explained recently during a guided tour, that the numbers of tulips in bouquets of flowers on Dutch paintings can be taken as a calendar – only a few tulips were shown before the crisis and many oft them afterwards!

Here comes the explanation: A virus was to blame for all - but nobody knew this. The virus caused the unpredictable patterns and the uncertainty of the appearance caused the financial bubble. The virus breaks the colors and was therefore called *Tulip Breaking Virus*, TBV.[9]

Financial crisis

How did the speculations end? What terminated the bubble? From one day to the next the hysteria broke down, it was the 2nd of February in 1637. Why? Nobody really knows. During the auctions no tulip bulbs were bedded for all of a sudden, nobody invested - or nobody came? Did nobody come because there was a sudden outbeak of the Bubonic Plague? Were people afraid of becoming infected? Did they avoid assemblies of many people, so that nobody did some bidding because nobody came? That sounds very plausible and it may be the reason for the end of the bubble - at least it would make a lot of sense to me.

The Plague showed up unexpectedly at various places - and also stopped MS Merian on her way to the religious colony so that she had to bribe the coachman to continue with the journey.[1,2]

There are many persiflages or mockery paintings, allegoric symbols of lazyness, money thrivers, drunkbolds, also hope and misery are represented as allegoric creatures on the so called Bad Waggons "Malle waggons" with Queen Flora in the center holding up the most expensive flower Semper Augustus, in a copper etching by Crispin van der Passe in 1637. Also a huge cap of an idiot designated as "Geckenkappe" is a caricaturo on the ongoing happenings. The Tulip is described as a garden whore, a goddess of bad guys, and flyers with mocking pictures about the diseased Flora were distributed. Even the Government initiated

activities and requested that the controversies among the different parties, the insolvent bidders and the suppliers, should be settled without asking justice at the courts, because there may have been too many trials. Even a settlement committee was founded. A percentage was established, which had to be paid for by the losers, amounting to 5% of the total cost.[8,9]

However it is unclear today how many people were really affected by the financial crisis, how many people ended up in poverty, pennyless with the only option for suicide - no numbers are known.

On my way to London I was approached by a colleague from the former German Democratic Republic, DDR. He told me, that before the Berlin Wall came down his mother bought bulbs of tulips and was promised that they would have stripes. She was so enthusiastic that she bought them but after two generations they were unicolored - and she blamed it to the regime - they always lie! No, in this not case they did not try to cheat, they just did know any better.

Epigenetics and a virus as cause

Clusius already noticed in1585 that "broken", multi-colored plants also slowly degenerated. "...any tulip thus changing its original colour is usually ruined afterwards and so wanted only to delight its master's eyes with this variety of colors before dying, as if to bid him a last farewell." Striped flowers tended to deteriorate and fianally die. He also noticed that uniformly colored flowers were healthy and lived longer. Furthermore, he observed that nutrients, selection of the soil, temperature, light and other environmental conditions influenced the outcome of the tulip patterns. He recommended a procedure called "rectification" of the flowers appearance through frequent changes of the soil, varying the planting depths so that the plant had to struggle with too much or too little soil, by applying too much or too little manuring, storing the bulbs in exposed conditions so that they would be acted upon by the rain, wind, sun, or extreme temperatures!

This impressive list of changes of environmental conditions proved one thing - the effect was not a genetic one but due to epigenetic modifications of the color. So Clusius was the first to discover and explicitly describe the phenomenon of epigenetics already in 1585. This is 430 years ago! The epigenetic effect was caused by a virus - the Tulip Breaking virus TBV, it breaks the colors, therefore this name. It took 400 years, until after World War II for the virus to be discovered.

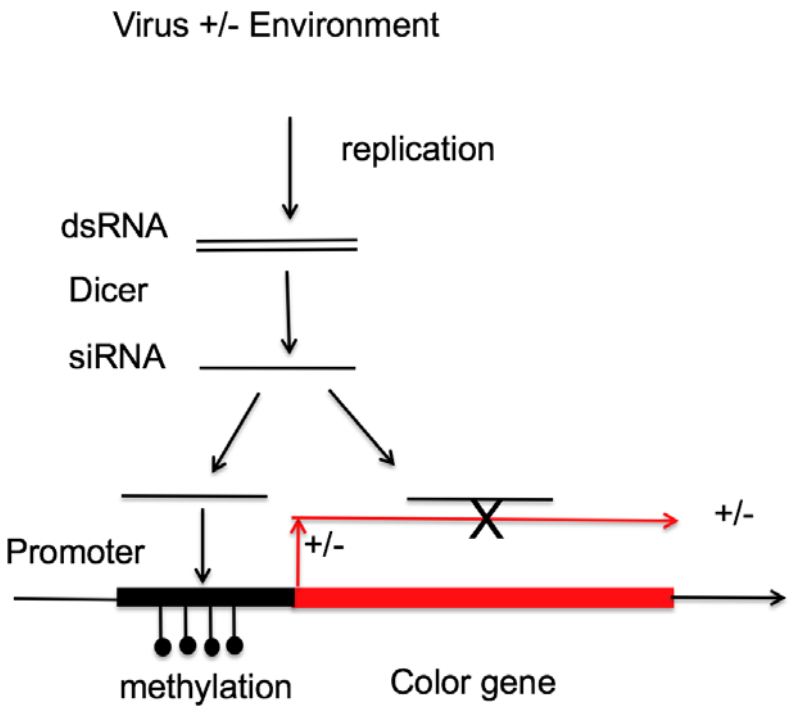

Fig. 2 – Hypothetical model of the effect of TBV on a color gene, RdDMT: RNA-dependent DNA Methyl Transferase, RISC: RNA-induced Silencing Complex, siRNA: silencing, dsRNA: double-stranded RNA.

Epigenetic changes as cause of colors were detected in the 1950ies for maize kernels by Barbara McClintock from Cold Spring Habor Laboratories.[3] The Laws of Gregor Mendel`s were known, but the color patterns did not obey them and it was the genius of McClintock`s to conclude that this was what is now known as epigenetic changes. These are transient changes not genetic mutations, only effective within the lifetime of a subject, not (normally) transmitted to the next generation. This she discovered already before the DNA double-helix was even determined by James D Waton, Sir Francis Crick and Maurice Wilkins in 1953. B. McClintock discovered that the colors of maize kernels were due to regulatory mechanisms of the color genes she designated as "control genes" which we describe today as promoters regulating gene expression. Changes in gene expression she attributed to the effect of "jumping genes". Today we describe jumping genes by computer programs as "cut-and paste", a piece of DNA is cut out and reinserted into the DNA genome, designated as transposable or mobile genetic elements. They are rudimentary "locked-in-viruses", which cannot leave a cell but can only move from one location to another one in the genome.[3] Plants are especially active till today with such active DNA transposable elements. Humans have not much of this mechanism left. Until today the field of transposable elements, their activation and silencing is a highly active research topic. Most surprising to me is the discovery of the environmental factors with the tulips, the phenomenon of epigenetics 430 years ago, which is still completely forgotten about! The tulip striped patterns are not fully understood even today.

Breeders today are trying to make Semper Augustus again. Surprising all of the former tulips have gone extinct and recently breeders eliminate tulips whenever they suspect some viruses to be present. There is no other way against the viruses but by eliminating the whole plants and the soil! Would there be modern ways of revitalizing a Semper Augutus? One would have to replace the unreproducible viral effects by stable genetics. If one uses the semen, the tulips are always unicolored because the viruses do not enter there. Then it takes about 10 years to grow tulips. If one then wanted to generate color patterns one would need to infect them with TBV. Then the old lottery game starts all over. No, there is no resurrected Semper Augustus. There is a "Rem's Sensation", a Rembrandt-like genetically modified tulip one can buy today. And striped tulips can be purchased today everywhere - but by genetic manipulations, they are stable mutants, not epigenetically caused any more. We can reconstruct mammoths which went extinct from a single hair and extraction of their DNA, sequencing, transfecting cells, growing embyos etc. and bring them back to life - but no Semper Augustus!

Since the year of 2000 when the human genome was first sequenced almost everything on earth, even the smog of Beijing has been sequenced (which contains microorganisms). So people tried to sequence the genomes of tulips - and ran into trouble. Researchers used the ancient tulip Carolus Clusius to determine the complete genome of tulips. This was a big task because the tulip genome is gigantic, it is tentimes as big as the human genome amounting to 30 Bio nucloetides, while we have 3.2 Bio of nucleotides. The analysis of a model plant genome was for simplicity reasons performed with the weed *arabidopsis thaliana*, which has only 125 Mio nucleotides.[13] The genetic complexity is high not only in tulips but also in maize, and other cultured plants such as rice or wheat. The accumulation of genes may result from breeding. In tulips the genome is almost tripled, three similar chromosomes accumulated, but did not quite stay identical but evolved separately to some extend. The plants can easily lose up to one third or even half of their genes, without much noticeable differences. In the case of wheat the bread did not taste as well!

DISCUSSION

A virus breaking the colors - how?

Viruses were discovered in 1892, whereby the *Tobacco Mosaic Virus* TMV[3,9] was among the first to be described. It was transmissible in the sap of many plants not only tobacco and caused changes of colors of leaves. Tobacco leaves were analyzed, the mottles were isolated, homogenized and passed through Chamberlin filters. The flow through contained contageous agents, later called viruses. Healthy leaves could become infected and mottled by the flow-through again, proving the presence of what was later called viruses, entities smaller than bacteria, only bacteria (not the viruses) were held back by the filters. TMV is one of the most well-studied viruses, it was isolated and the first virus to be crystallized by Wendell Stanley in 1935. TMV

started German research in virology by A. Butenandt around that time.

TBV is a member of the TMV family. But still it took until after World War II until TMV was determined to paly a role in breaking the colors of the tulips. Nobody had reported earlier on that the disease was communicable, transmissible, that an agent may have been involved, that hands of gardeners, tools or dividing the bulbs could have spread some kind of contageous agent - no virus. Not even Clusius did!

What characterizes these viruses and make them change colors? First of all, TMV and the related TBV belong to the family of Potyviruses, the Potato Y virus family. They are closely related, extremely stable and can survive on dry sufaces for up to 50 years and restart replicating again after that. They are present in every salad and each salad dish will lead to uptake of 10^9, viruses per gram. They are present in Chili sauce in salad dressing in California coming all the way from the chili fields in the Philippines, still able to replicate - but they do not cause diseases in humans. We are lucky. After a dish the virus is secreted intact with our feces.[3] The virus is still infectious after passage through our gastrointestinal tract. Could the virus infect plants again? Yes - except plants cannot be easily infected and have borks or other protections. Also tabacco smoke can transmit the virus. Wounds or vectors are required for infections, such as Aphids in the case of the tulips. There is a group of several related viruses, the *Lily Mottle Virus* (LMoV), *Lily Symptonless Virus*, only those two together would do harm to lilies and also to tulips. Then there is the *Potato Ring Spot Virus*, *Potato Spindle Tuber Virus, Cucumber mosaic Virus*, and the TBV- all infecting plants and affecting crops etc. There are two TBVs, a mild and a severe form, MTBV and STBV, referring to their effect on colors, mild or strong changes.[9]

One virus by itself does not kill the host, two or even three will, however be lethal. Such co-infections occurred in Holland and then caused the death of the tulips. They code for only 3.5 genes but they can perform everything required for the virus to replicate and survive. The 0.5 gene refers to a double function of one of the genes. It can have two different lengths and thereby two different characteristics, typical minimalistic and economical principles established by the viruses in many cases, here for recognition of the host and binding to the genomic viral RNA. The viruses are rodlike structures, piling up with a coat or capsid protein winding around the inner single-stranded RNA. During replication one large single polyprotein is synthesized and processed to the final products by protease activities. The sequence for several of these viruses is known, best of TMV, about 6400 nucleotides. Nothing compared to tulip genomes! They are so easy to produce in the laboratory that they are presently tested as potential electrical cables.[3]

CONCLUSION

Hypothetical Molecular Mechanism

What would I expect is going on with TBV and tulips based on the observations on epigenetics by B McClintock or other non-Mendelian mechanisms?[3,13] What about defense mechanisms?[14] My curiosity was activated. Does TBV affect the promoter of a color gene and cause epigenetic changes? Such changes are known to involve methylation by an RNA-dependent DNA Methyltransferase (RdDMT).[10] The methyl groups are deregulating the promoter and affecting gene expression. If the gene is a color gene we can see it with our own eyes! It is difficult to show methylation patterns of promoters. One would have to compare the methylation patterns with and without TBV activity (by bisulfite analsis).[3] Or does TBV RNA cause post transciptional silencing of a color gene`s mRNA by a mechanism desginated as silencing?[11,12] Thereby an RNA such as the viral RNA could bind to the color mRNA and activate molecular scissors in an RNA-induced Silencing Complex RISC. Can one show that there is some sequence homology between the color gene and some TBV sequences? That would indicate that the virus can bind there and destroy color gene expression (Fig.2). So in silico studies could be confirmed by experimentl procedures, whereby the TBV would have to be expressed by recombinant DNA technologies. As color gene anthocyanin has been described. Its synthesis is complicated and involves about 12 other genes and their expression. TBV could interact with any or several of them.[3] The tulip genome needs to be known for such a study. As a control one would have to make a construct and transfect it into tulip cells to demonstrate that the anticipated gene is really shut off. Then the phenomenon of striped tulips would be proven to be an epigenetic effect. That is exactly the same effect explaining the

colored maize kernels analyzed by B. McClintock. But the biochemistry has not been performed yet with TBV and tulip genomes. I am getting ready for that study with the MPI for Molecular Genetics in Berlin now. Other mechanisms may have to be considered, activators and inhibitors interacting with each other depending on the geometry of a body, be it the growth cone of a plant after a virus infection or genetically determined patterns on zebras or fish or dots on the leopard.[15-17]

REFERENCES

1. B. Friedewald, „MS Merians Reise zu den Schmetterlingen“, Prestel Press, 2015.
2. K. Wettengel Kurt, “Maria Sibylla Merian”, Gerd Hatje Press.
3. K. Moelling, “More Freinds than Foes, Fantastic Stories about viruses”, World Scientific Press, Singapore, 2016.
4. T. Ribi, “500 years Conrad Gessner Neue Zürcher Zeitung”, 2016.
5. F. Egmond, “The World of Carolus Clusius: Natural History in the Making”, London: Pickering & Chatto, 2010.
6. P. M. Garber, “Famous First Bubbles: The Fundamentals of Early Manias”, Cambridge: MIT Press, 2000.
7. M. Dash, “Tulipomania: The Story of the World's Most Coveted Flower and the Extraordinary Passions It Aroused”, London: Gollancz, 1999.
8. M. Pollan, “Botany of Desire: A Plant`s Eye View of the World”, New York: Random House 2001.
9. J. A. Lesnaw and S. A. Ghabrial, *Plant Disease*, **2000,** *84***,** 1052 - 1060.
10. **M.** Alleman, L. Sidorenko, K. McGinnis, K. Seshadri, V. Dorweiler, J.E. White, J. Sikkink K. V.L. Chandler, *Nature*, **2006**, *442*, 295-298.
11. D. C. Baulcombe and C. Dean C, *Biol.*, **2014**, *6,* a019471.
12. A. Fire, *Trends Genet.*, **1999**, *15*, 358-363.
13. S. J. Lolle, J.L.Victor, J.M. Young, R.E Pruitt, *Nature*, **2005**, *434*, 505-511.
14. K. Moelling and F. Broecker, *Ann. N. Y. Acad. Sci.,* **2015**, *1341*, 126-135.
15. J. D. Murray, *Scientific Am.*, **1988**, *3,*80-87.
16. A. Turing, *Philos. Trans. R. Soc.,* **1952**, *237*, 37-72.
17. A. P. Singh and C. Nüsslein-Volhard, *Curr. Biology,* **2015**, *25*, R81- R92.