Reflections on the Nature of Genius on Occasion of 300th Anniversary of Mikhail Lomonosov (1711-1765)

Which are the most complex sciences of nowadays? How the Chinook-47D helicopter came out of atmospheric electricity studies? What is the difference between “Type A” and “Type B” geniuses? How mosaics and the finest European porcelains are related to the law of conservation of matter? Whom does Benjamin Franklin meet in the downtown Batavia? Why observation of the Venus’s atmosphere during its transit over Sun’s disc on June 5, 2012 will be as hard as in May 26, 1761 when it was discovered? How many people are needed to reform a grammar, to invent a new type of reflector telescope, to estimate the age of the Earth to be at least 399,000 years on base of scientific evidences, to perform more than 4000 chemical tests in the Russia’s first national laboratory, organize unprecedented Arctic exploration expedition and win a public completion among three best national poets? What is in common between Bob Wilson and Michelangelo Buonarotti? All that and much more in the lecture on the occasion of the 300th anniversary of the titanic figure of Russian Enlightenment – Mikhail Lomonosov (1711-1765). You are welcome to attend for a chance in just under 60 minutes to become one of only a few hundred Americans most knowledgeable in the achievements of a true Russian genius.
Tercentennial Anniversary of LOMONOSOV

Nov 19, 2011
Lomonosov - 300

• Who is he
• Life
• Science
• Complexity of Science
• What does make a genius?
• Anecdotes
• Then and Now
Mikhail Vasil’evich LOMONOSOV
Nov 19, 1711 – Apr 15, 1765

- Physicist and Chemist
- Poet and Artist
- Engineer and Entrepreneur
- Courtier and Administrator
- Philologist and Astronomer
- Geologist and Mineralogist
“Passionary Power” of Russian Ethnos

Power (a.u.)

1700  1750  1800  1850  1900  1950  2000

Lomonosov Tercentennial
Pushkin on Lomonosov

«...между Петром I и Екатериною II он один является самобытным сподвижником просвещения. Он создал первый университет; он, лучше сказать, сам был первым нашим университетом”

А.С.Пушкин 1835

“...between Peter I and Catherine II, he (Lomonosov) was the original champion of the Enlightenment. He founded the first University: better to say, he himself was our first University...”
Named After Lomonosov

- **Moscow State University** – the top one in Russia
- **Town (near St. Petersburg)**, home village in the North
- **Range** in Arctic ocean, ocean stream, peninsula, Moon crater, mineral, crayfish species
- Three other Universities
- One Theater
- **Russian State Porcelain Factory**
- 8 Schools
- 54 streets and squares
- Russian State-wide Tercentennial celebration in 2011
“...What's in my name for you?”

Pushkin

- **Mikhail** (1st name)
  - Very typical Russian/Slavic
  - Michael
  - Of choice for Nov. 19 DOB

- **Vasil’evich** (2nd name)
  - Father’s name - Vasily
  - “State-peasant” → fisherman

- **Lomonosov** (family name)
  - Two possible meanings →

“Ломоносов” = breaking noses

“Ломонос” = Clematis
Roots & Early Life

1711-1730

1730-1736

Lomonosov Tercentennial
School & Scientific Tradition

Gottfried Wilhelm von Leibniz
1646 – 1716

Christian Wolff
1679 - 1754

Mikhail Lomonosov
1711 - 1765

In Germany
1737-1741

Lomonosov Tercentennial
### Lomonosov: 23 years in St.P’s Academy

- **Adjunct** Professor of Physics  St.Petersburg Academy  
  - 1742
- Dissertation “On origins of heat and cold”  
  - 1745  
  (refereed and strongly supported by Leonhard Euler)
- **Academician** (Professor) of St.Petersburg Academy  
  - 1745
- Formulation and experimental proof of law of  
  conservation of matter and movements  
  - 1748
- Physical Chemistry  
  - 1752
- *Measurements* of atmospheric electricity and  
  theory of electricity (with G.Richmann)  
  - 1753
- First working model of helicopter  
  - 1754
- Novel concept of Reflector telescope  
  - 1756
- Theoretical concept of Earthquakes’ origin  
  of minerals, review of geological observations  
  - 1757
- Solid mercury obtained & studied (with I.Braun)  
  - 1759
- Discovery of Venus atmosphere  
  - 1761
- Theoretical justification of the Arctic path expedition  
  - 1763-65
Scientific Academies

- Platonic Academy in Athens ~380’s BC
- Accademia dei Lincei 1603
- Royal Society of London 1660
- German Academy of Sciences Leopoldina 1662
- French Academy of Sciences 1666
- Prussia Academy of Sciences Berlin 1700
- St-Petersburg Academy of Sciences 1724
- Royal Swedish Academy of Sciences 1739
- American Philosophical Society 1743
- Göttingen Academy of Sciences 1751
- Dutch Academy of Arts and Sciences 1806
- Academie Des Sciences Wien 1847
- National Academy of Sciences USA 1863
Saint-Petersburg Academy

1724

fully sponsored by the state (poll-taxes from 3 towns)

Lomonosov was the 1st Russian Academician (1745)

- Imperial Academy of Sciences 1747
- Russian Academy of Sciences 1917
- USSR Academy of Sciences 1925
- Russian Academy of Sciences 1991
Lomonosov Complete Works 1950-83

6 volumes out 11 on Natural Sciences: Physics, Chemistry, Astronomy, Geology, Geography
Lomonosov’s Method

• He was [a Thinker + an Experimenter] :
  – His theories and hypotheses were based on tests and experiments, which he planned, prepared and carried out himself.
• He used to work on each of his many research topics for many years if not decades
• Always tried to turn his scientific discoveries into practice or inventions
Lomonosov’s Major Results (1)

• New science of *Physical Chemistry* (1752)
  – on base of corpuscular-mechanical view
  – theory of light and color
  – the concept of *absolute cold*

• Experimental proof of the law of conservation of matter:
  – the amendment to R. Boyle

• Experiments on the freezing of mercury
  – with I. Brown
His Corpuscular-Mechanical Views

- Heat is not a liquid, it is a measure of rotation and motion of molecules
- Concept of **absolute cold** – no rotation or motion
- (out of fashion 1760-1840)

\[ P = \frac{RT}{(V-b)} \]

R. Clausius 1850’s
Chemical-Physical Laboratory

- Russia’s first national research lab
- Senate granted 1500 rubles
- >4000 tests by himself!
- Famous test in 1756
  - Repeated by Lavoisier 1773
R. Boyle 1673: lead weight increased after heating (vessel opened) \(\rightarrow\) “caloric particles penetrated glass”

Lomonosov 1756: lead weight remained the same when vessel sealed \(\rightarrow\) no caloric particles, matter conserved (in chemical reaction):

“...all changes that we encounter in nature proceed so that... however much matter is added to a body, as much is taken away from another ... since this is the general law of nature, it is also found in the rules of motion: a body loses as much motion as it gives to another body”.  

letter to Leonhard Euler
Cold weather -26 C
Used mix of snow and concentrated nitric acid
Together with I.Braun
- Report Royal Society
- Priority battle with F.U.T.Epinus
Against Newton’s Corpuscular Theory of Light

Many contemporaries of Lomonosov considered light as a very fine material. “But if this is the case,” asked Lomonosov, “then how do the light rays from many sources, if they do not collide, pass through glass?”
Mosaics “Battle of Poltava” (1764)
Lomonosov’s Major Results (2)

- Electricity studies 1745-1760’s
  - first quantitative measurement of electricity
  - Two measuring instruments (scales and electrometer) - with G. Richman
  - Automatic “lightning-meter” proposal
  - helicopter for atmospheric research

- The theory of air electricity
  - The friction in the vertical air currents
  - Applied to Northern Lights/ auroras

- Color theory in electric discharge
Lomonosov’s Electricity Experiments

dead of Georg Richter

07/26/1753

Richman electrometer
Georg Richman and Lomonosov

Lomonosov response – device for automatic detection of max charge →
Air density increase due to lower temperature in upper atmosphere is ~2.5 times stronger than density decrease due to high elevation.
Explanation of Northern Lights
1754 Lomonosov’s “Aerodynamic Machine”

Leonardo’s “airscrew”

Chinese top 4th cent. A.D.

* counter-rotating blades
** for atmospheric research
also in *Yak-24, Piasecki H-21, all Kamov’s helicopters*
Lomonosov’s Major Results (3)

• **Discovery of atmosphere of Venus**
  – during the 1761 Transit of Venus

• **Inventions**
  – A telescope with one lens ("Herschellian")
  – Sideroscope
  – “Night-vision tube”
  – Method to determine the position of the sun on the ship
  – Automatic course recorder of a ship
  – Many others
Transit of Venus June 1761

1761 – 176 observers at 117 stations (including 5 Russian astronomers in 3 cities all over Russia); major goal – determine distance to the Sun; very rare event – ToV in 1769, 1876, 1884 and 2004 ...
Lomonosov’s Actions in 1761

Important! – he used lightly smoked glass

1762 telescope by Lomonosov
Lomonosov Discovery of Atmosphere of Venus

Swedish 1-m Solar Telescope, 08 June 2004

Lomonosov Tercentennial
Transit of Venus June 5-6, 2012

You can see it, your kids can see it, your neighbor kids can see it!

250th Anniversary of the Discovery of Venus Atmosphere by Lomonosov
Newton-Teleskop

I. Newton 1668

M. Lomonosov 1756
Lomonosov Reflector Telescope

• Lomonosov’s concept 1756
• Successful model 1762

• William Hershel 1789
Night-Vision Tube 1756

• Large objective + 8mm eye-piece
• MVL’s explanations denied
  – by Epinus, Rumobvsky, Grishow
  – Ricco’s law 1877: $B_{\text{min}} = \text{const} / \text{Area}$
• 3 built for Arctic expedition 1765
“Siderostat”

flat mirror

W. Herschel
1789

M. Lomonosov
1759
Lomonosov: Beyond Natural Sciences

- Odes to Empresses 1739, 1746, 1763
- Founded Moscow University 1755
- Arctic Sea Expedition 1763
- Russian Grammar 1754
- Mosaics Factory 1752-1764
- Academy Management (top 3) 1757-1765
- Russian History 1765
- Demography Analysis 1761

- Age difference (15/2), no forced marriages, 3rd time widowers, monks age limit, baptism in warm water, move holydays, pharmacies, birth assistance → 10 million/20 yrs (pop. 22 million in 1750) double the rate
POLL #1

• How many non-Russian speakers are in the audience? (raise your hand, please)
• How many of you HAVE heard of Lomonosov?
• How many Russian-speakers are in the audience?
• How many of you have NOT heard of Lomonosov?
History of Science in Russia
Batavia, Lomonosov and Franklin

Self-Made Man by Bobby Carlyle
Lomonosov and Ben Franklin

Similar legacies in Russia and US:
Key figures of Enlightenment & 1st orig. scientists

Britannica 1954  ¼ page
БСЭ (Sov.Encicl.1978)  6 pages
Wiki Eng  4 pages
Wiki Rus  35 pages

5 pages
2 pages
20 pages
5 pages
New culturonomics tool:

- [http://books.google.com/ngrams](http://books.google.com/ngrams)

- Frequency of appearance of the word or combination of words in the published books vs year

- >5M digitized books (5%), 500B words, 7 languages
Three Scientific Geniuses: English, German, Russian book collections

![Graph showing frequency of appearance in books for Leibniz, Newton, and Lomonosov from 1650 to 2000.](image)
Most Prominent Russian Scientists

Russian book collection

![Graph showing frequency of appearance in books for Lomonosov, Mendeleev, and Pavlov]

- Lomonosov
- Mendeleev
- Pavlov

Frequency of Appearance in Books

Lomonosov Tercentennial
Lomonosov’s Tercentennial 2011

• Lomonosov's 2011 celebration is state-wide in Russia - preparations started in 2006 per Russian President's order

• The plan of celebration lists 36 actions for Russian Ministries of Foreign Affairs, Education and Science, Postal Office, Russian Academy of Sciences, Arkahangelsk Governor and includes:
  – All-Russian "scientific competition" of young scientists
  – "Lomonosov classes" in every Russian school
  – Postal stamps, medals, UN and UNESCO events
  – Russian Chemistry Olympiad in Arkhangelsk
  – "Lomonosovskie Chteniya" (Lomonosov's Seminars) in Russia and abroad
  – Number of Russian and Int'l conferences on subjects of chemistry, physics, fleet, geography, etc
  – Books on Lomonosov including new popular biography
  – Movie on his life
  – New edition of Lomonosov's works
  – Expositions in Russia and abroad

• City of Arkhangelsk (birthplace of Lomonosov) has their own list of celebration events and actions (some 100 items long).
On the Nature of Scientific Genius

• I will need to guide you through a concept of complexity of sciences and a little bit of math
An Example of Complex System

“Moore’s Law”

number of transistors on one chip doubles every ~2 years
Theorem of Complex Systems

The system is complex $\rightarrow$ many problems and parameters $\rightarrow$

one can not solve all the problems at once $\rightarrow$

address them step by step

$Fractional \ Gain \ per \ steps \ 1 \rightarrow (1 + F)$

$after \ M \ steps \ (1 + F)^M \approx e^{FM}$, etc.

...or in time $\rightarrow$

$L(after \ time \ T) = L_0 \times \exp(T / C)$

$C$ (Complexity) = # years to e-fold progress

E.g. “Moore’s Law” $\rightarrow C=\frac{2\text{yrs}}{\ln(2 \text{ factor})}=2.9$
Thermonuclear Reactors

C = 2.4

factor >100,000 over ~30 years
Moore’s Law, LEDs, SuperComputers

C=2.9
C=1.6
C=3.3
Number of Observed Galaxies

C = 3.0

factor ~10,000 over ~25 years
Ultra-High Power Lasers

C = 3.3

factor ~1000 over ~25 years
Protein Structures deposited in PDB

C = 4.2

factor ~1000 over ~25 years
“Complexities” of Sciences

- Supercomputers: 1.6
- Fusion Reactors: 2.4
- Moore’s law: 2.9
- Galaxies Surveyed: 3.0
- LED light: 3.3
- Laser power: 3.3
- Protein structures: 4.2
- Exoplanet search: 4.2

“easier”
POLL #2

• How many of you think that accelerators are harder (more complex) than “Moore’s Law”?

• How many of you think that accelerators are easier (less complex) than “Moore’s Law”?
Beam Energy

C_proton = 4.3
C_electron = 5.2

factor ~10,000,000 over ~80 years
# Record Luminosity of Colliders

![Graph showing luminosity of colliders over time](image)

## Luminosity (10^{30} \text{ cm}^{-2} \text{s}^{-1})

<table>
<thead>
<tr>
<th>Experiment</th>
<th>$C$, years $\pm$ error</th>
<th>Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLC $e^+e^-$</td>
<td>$1.6 \pm 0.1$</td>
<td>1989–1997</td>
</tr>
<tr>
<td>Tevatron Run II $p\bar{p}$</td>
<td>$2.0 \pm 0.2$</td>
<td>2002–2007</td>
</tr>
<tr>
<td>RHIC $p-p$</td>
<td>$2.2 \pm 0.3$</td>
<td>2000–2004</td>
</tr>
<tr>
<td>HERA $p-e$</td>
<td>$2.8 \pm 0.4$</td>
<td>1992–2005</td>
</tr>
<tr>
<td>SppS $p-\bar{p}$</td>
<td>$3.3 \pm 0.2$</td>
<td>1982–1990</td>
</tr>
<tr>
<td>LEP $e^+e^-$</td>
<td>$3.3 \pm 0.3$</td>
<td>1989–1995</td>
</tr>
<tr>
<td>ISR $p-p$</td>
<td>$3.7 \pm 0.3$</td>
<td>1972–1982</td>
</tr>
<tr>
<td>CESR $e^+e^-$</td>
<td>$4.4 \pm 0.4$</td>
<td>1984–1997</td>
</tr>
</tbody>
</table>

**$C=2.0$**
Back to Moore’s Law – Who Started it?

1947       Bardeen, Brattain
“Genius Effect”

\[ D = \ln \left( \frac{\text{After}}{\text{Before}} \right) \]
To be able to compare historical figures, more useful is:

"Genius Formula"

$$\text{Genius} = T \times B \times D$$

- $\ln(\text{Time})$: duration of impact
- Breadth: # of areas
- Depth: of impact = $\ln(\text{After/Before})$
“B-factor” Scientific Geniuses:

“Type A” and “Type B”

**“Type A”:**
- Euler
- Lavoisier
- Gauss
- Maxwell
- Riemann
- Mendeleev
- Pavlov
- Mendel
- Rutherford
- Plank
- Einstein
- Kolmogorov
- Feynman,

**“Type B”:**
- Aristotle
- Leonardo
- Descartes
- Newton
- Leibniz
- Lomonosov
- Franklin
- Poincare
- von Neumann

Fields of Science

Log (Impact)
Lomonosov’s $G$:

- Grammar $\ln(100 \text{ yrs}) \times \ln(2) = 3$
- Poetry $\ln(60 \text{ yrs}) \times 1/3 = 1.3$
- Chemistry $\ln(20 \text{ yrs}) \times 0.1 = 0.3$
- Optics $\ln(100 \text{ yrs}) \times 1/20 = 0.2$
- Venus $\ln(60 \text{ yrs}) \times 1/5 = 0.8$
- Geography $\ln(60 \text{ yrs}) \times 1/4 = 0.9$
- History $\ln(250 \text{ yrs}) \times 1/10 = 0.5$

**TOTAL $G = 7 \pm 2$**
Genius Coefficients \( G = T \times B \times D \)

- Scientist(me) \(~0.03\)
- Inventors \(0.1-2\)
- Nobelists \(0.3-4\)
- Pithagoras, Aristotle, Newton, Lomonosov, Einstein \(4-9\)
- Sheakespeare, Pushkin \(7-12\)
- Biblical God \(123\)
- Big Bang \(300-650\)

\[ \ln(7519\text{ yrs}) \times 6 \times \ln(10) \]

\[ \ln(14\text{ BYrs}) \times \ln(10^6) \]
~200 sciences

Global Genius Product

GGP ~ (4-10) per year
Limitations of the “Genius Formula”

\[ \ln(T) \times B \times \ln(\text{After/Before}) \]

• how to account geniuses in art, music, etc?

• **Baseline** choice issue
  – eg (my) family of 4 with two kids
  – by my definition

\[
G = \ln(13\text{yrs}) \times 2\text{kids} \times \ln\left(\frac{7B+1}{7B}\right) = 1 \times 10^{-9}
\]

– by (my wife’s) definition

\[
G = \ln(13\text{yrs}) \times 2\text{kids} \times \ln(4/2) = 3.5
\]
Other Characteristics of a Genius
Every Genius Has (Impressive) Story!

Eppur si muove (still it moves)

Lomonosov Tercentennial
German hussars enlist drunk Lomonosov to the service of the King of Prussia

Lomonosov's prophetic dream about his father

Three sailors' attempt to rob Lomonosov

Hey, he's a real polymath!

…fighting and writing!
Another Sign of Genius: Rebelliousness

Petr Kapitsa, USSR
1978 Nobel Prize
Superfluid Helium

• Kapitsa On Geniuses:
  – Lomonosov vs Schumacher
  – Michelangelo and Medici
  – Kapitsa himself and Beriya
Robert R. Wilson
(1914–2000)

Accelerator director quits over cash shortage

The Universities Research Association, which runs the US Fermi National Accelerator Laboratory (Fermilab), has accepted the resignation of Dr Robert R. Wilson. Wilson, Fermilab’s director, quit as a protest against the US government’s refusal to fund the early completion of equipment to raise the proton beam energies at the accelerator.

New Scientist 2 March 1978

Dear Colleague,

An all too common failing of large institutions is to fall into the bureaucratic morass - complicated procedures, red tape, and all that. That's terrible.

Let's try hard to keep the good old Can-do informal spirit of Fermilab alive!

Bob Wilson
Final Words...

• The system of entire humankind is very complex
  – Both in terms of hierarchy of connections and $C$-coefficients

• We see that it is progressing, moving somewhere
  – Generates new knowledge, ideas, arts, inventions, etc

• It’s not fully clear yet how world’s genius (GGP - global genius product) is created
  – it is hard to get there, so we should not lose positions
  – advanced society is needed for genius to appear
  – on the other hand, geniuses do transform the society

• To understand who we are, we must comprehend our geniuses of a type of Galileo, Newton, Einstein, Leibniz, Franklin, and Lomonosov
With that –

I congratulate all of us with 300th anniversary of Mikhail Lomonosov!

Thank you for your attention!