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"Fight the Fear with the Facts!"

Ranga Yogeshwar*

"We hold these truths to be self-evident, that all men are created equal." These words mark the beginning of the Declaration of Independence of the United States of America. What is remarkable here is the formulation of "self-evidence" as an invitation to a social consensus that should be accepted by all parties. It is the basis of our democracy and a central element of the Enlightenment. Science has also firmly adopted this element within its own universe. In a complex system of peer reviewing, transparent reproducibility of results, and disclosure of its methods, a resilient process for scientific knowledge has emerged. Today, facts are based on countless tests and critical arguments within the scientific community and mark the result of an immense distillation process in the common search for truth. This well-established approach is self-evident to all participants. Within our scientific world there is consensus on the grammar of this methodology.

However, the dissemination of alternative facts has significantly grown as an increasing number of people have access to multimedia channels and the opportunity to post and broadcast their views. Therefore, we are currently experiencing a growing disregard for established scientific facts and even face questioning of the scientific system itself. The climate debate is a particularly powerful example of this. In their *Consensus Handbook* published in 2018, the authors note a remarkable gap:

> Despite many studies confirming the overwhelming scientific consensus on climate change, there is a large gap between the 97% consensus within science and the public's perception of the consensus. On average, people assume that only about 67% of climate scientists see humans as the cause of global warming. Even more worrying: only 13% of Americans know that the consensus is over 90%. This misjudgment is not only true for the general public. Even many science teachers are not aware of the consensus. The unfortunate consequence of this is that many

teachers are equally opposed to current climate research when it comes to climate change.[1]

Thus, while the right of all people to benefit from scientific progress and its applications is recognized both in the Universal Declaration of Human Rights and in Article 15 of the International Covenant on Economic, Social and Cultural Rights (ICESCR), a broad questioning of scientific unity has emerged in several societies. Science itself is the focus of criticism and is confronted in many places with doubt – from climate sceptics to vaccination opponents, and from conspiracy supporters of chemtrails to citizens who turn their backs on classical medicine and follow obscure miracle healers.

The vehemence of this rejection of science has increased to such an extent that even scientists themselves are now actively raising their voices: On April 22, 2017, I engaged in the March for Science in Berlin. Similar demonstrations also took place in other cities. Some 11,000 people, including several presidents of German science organizations, the Mayor of Berlin, and many impassioned students, spoke out against alternative facts and in favour of a fact-based policy. As we walked along the avenue *Unter den Linden* towards the Brandenburg Gate, I realized how absurd the scenery was: in the midst of an enlightened industrial nation embracing the fruits of science, we had to demonstrate for the most elementary principles of evidence through scientific facts!

But how could this discrepancy occur? What factors led to this growing scientific scepticism? What role does the media play and is science itself partly to blame for this development? In this chapter, I would like to highlight some aspects of this apparently disturbed science communication within a greater context.

11.1 OUR PERCEPTIONS DO NOT CORRESPOND TO REALITY, BUT ARE INCREASINGLY SHAPED BY THE MEDIA

In 2017, Sinan Aral and his colleagues from the Massachusetts Institute of Technology (MIT) conducted a study[2] that analyzed how news spread on Twitter between 2006 and 2017. Their findings were worrying: on average, news that had been verified[3] as true took six times as long to reach 1,500 users than news verified to be false, and furthermore, false claims were shared 70 percent more often than correct information. "Falsehood diffused significantly farther, faster, deeper, and more broadly than the truth in all categories." The most striking thing was that the conventional wisdom that bots accelerated the spread of falsehood more than

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[1]   J. Cook, S. van der Linden, E. Maibach, and S. Lewandowsky The Consensus Handbook (2018). (www .climatechangecommunication.org/all/consensus-handbook), p. 4.

[2]   http://ide.mit.edu/sites/default/files/publications/2017%20IDE%20Research%20Brief%20False% 20News.pdf.

[3]   News items used in the study were verified as true or false using information from six independent fact-checking organizations that exhibited 95 percent to 98 percent agreement on the classifications.

humans was wrong: "humans, not robots, are more likely responsible for the dramatic spread of false news." "Fake news" generates higher instances of emotional response, for example surprise or the perception of novelty, and thus substantially boosts click rates. In an interview with Sinan Aral, he explained to me that online portals financed by advertising in particular intensify this process, as they directly profit from the higher click rates induced by this cognitive effect.

The visibility of the respective content depends on the economic rules of a platform: while Facebook, Google, YouTube or Twitter may appear to be free of charge for the user, their business model focuses on their monetization as advertising platforms. The users themselves are the products as their data provides the basis for targeted advertising. The primary intention of social networks is therefore not mutual exchange and "connecting the world" as is often claimed, but rather to maximize the interaction of the user with tailored advertisements. Content that is frequently shared and viewed is automatically prioritized by algorithms and thus becomes even more visible.

Click rates, along with viewing duration and other parameters such as interactivity, flow into an algorithm and thereby determines the placement of the respective content. For YouTubers and Influencers, posted videos are even classified into different lucrative categories by algorithms. Depending on the content, you earn different amounts for the same number of clicks.

This focus on click-through rates automatically becomes an information filter. The focus is not on the content itself or its social relevance, but on a setup optimized for the algorithm, with the goal of maximizing advertising reach and thus the generation of higher income for the influencer. The grammar of these platforms determines the content. What began years ago in classic television media with an optimization of the audience flow has now developed into an art in its own right: search engine optimization (SEO), channel optimization, traffic control and keyword selection determine the reach on the net and thus the visibility of the information. All this has as its central purpose the maximization of user loyalty and retention time, since this forms the basis of the underlying business model of these platforms. The intensity of content-generation also plays an important role: Those who post only sporadically are downgraded by the algorithm and eventually end up in digital obscurity. Continuous activity, on the other hand, increases the reach of posted material. Out of this constraint, the content profile changes. The user does not post because they have something specific to say, but rather because the algorithm demands they be active. Through automatic reminders, the user is constantly encouraged by the platform to update their posts. The numerical recording and evaluation of page views, likes, reach, and responsiveness further fuels a spiral of excitement. Everything needs to be fast hence there is no time for pausing, questioning, and reflecting.

Interestingly, all this lacks any trace of transparency: companies like Google, Facebook, and Twitter do not disclose their internal modus operandi and so, even

famous YouTubers and Influencers operate within a space that is digitally opaque. Instead of working with clear criteria and facts as a basis for the decision processes concerning the classification and evaluation of their videos, decisions are communicated to them as a result of the "almighty algorithm." No outsider knows the underlying mechanisms of these algorithms. This means that the world's largest video network lacks a culture of responsibility, openness, and accountability. There is no true communication with responsible "editors" and it is remarkable that the scene has not yet publicly protested, although a large number of YouTubers criticize this "algorithmic" handling. What would happen in the real working world, if employees without transparent criteria and rules were paid differently according to almost arbitrary arguments?

11.2 THE INSCRUTABLE ALGORITHMS INCREASINGLY DETERMINE THE CONTENT, BUT SO FAR, WE HAVE DEALT TOO LITTLE WITH THE CONSEQUENCES OF THIS CHANGED GRAMMAR

Even in the classical media world, content has been used as bait for advertising, but this interaction has thus far been subject to clear rules: Advertisements had to be labelled as such and journalistic work followed a clearly formulated code, rooted in principles such as truthfulness, due diligence, and the clear separation of advertising and editorial work. This agreement provided the freedom for journalistic independence despite the commercial basis of a newspaper. Although advertising revenue indirectly financed journalistic research, the editorial part remained largely unaffected.

In the new digital world of communication, these protected information spaces have disappeared. The celebrated Influencers are essentially masters of surreptitious advertising, for this is precisely where their business model lies. The world of colorful irrelevance is soaked in advertising impulses. What matters are the number of followers, and the larger the community, the more potent the advertising effect in the selected target group. In order for this to work, the algorithm has to be fed as optimally as possible. The medium shapes the content as only such content that fulfils the logic of the algorithms has a chance of reaching a wide audience. Therefore, content is determined by the commercial objectives of the algorithm's coders and not by any journalistic criteria such as social relevance. Modern media focus on a new kind of business based on excitement.

Players such as Google took over the classical advertising business and professionalized it. The precise crystallization and addressing of target groups, the numerical accuracy of campaigns, the integration and targeted forwarding of buying impulses, the timely evaluation of advertising activities – all of these are not commonly offered by classic media. The user reveals their activities and interests and their data influences the information streams they get to see. This feedback automatically leads to the isolation and profiling of the individual. How far we have come in terms

of targeting has been recently shown in a revealing experiment: As part of its "Privacy Project," the *New York Times* bought targeted Internet advertising.[4] The newspaper "picked 16 categories (like registered Democrats or people trying to lose weight) and targeted ads at people in them." However, instead of trying to sell products or services, they "used the ads to reveal the invisible information itself." For example: "This ad believes that you are male, currently paying off your debts, but often shop in luxury shops." The fine granularity of data captured allows, when combined with predictive algorithms, the ever more precise addressing of the individual, despite promised anonymity.[5] This "surveillance capitalism"[6] is the core business of digital platforms. The prediction of the user's coming consumer desire becomes more and more accurate through better models and what, at the moment, still appears to be pure observation can easily degenerate into active manipulation through interspersed information.

11.3 THESE INTELLIGENT MEDIA DO NOT INFORM, BUT CHANGE AND SHAPE THE BEHAVIOR OF THEIR USERS

What emerges here is a widespread attack on free will. The consistent application of these tools within the political arena could end any hope of free democracies. Internet platforms are becoming more and more powerful and at the same time their traditional media opponents, the free press, are dissolving. The newspaper and magazine industries are facing a dramatic decline in revenues and circulation figures. Larger publishers are securing their own survival with new digital business models, decoupling the old advertising business and setting up separate commercial platforms, job exchanges, real estate portals, or news aggregators whose algorithms reflect the individual interests of users. This change threatens not only the existence of the traditional media industry, but also that of critical journalism itself as the digital world currently lacks resilient business models for independent journalism.

11.4 JOURNALISM IS REDUCED TO A COMMERCIAL EXCITATION BUSINESS

In the current transition phase between old and new media worlds, the categories of the digital platforms also infect the working basis of traditional media. We can all follow the fierce struggle for existence through circulation and quotas, which results in an increasingly hysterical press. The endless scandal-mongering and

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[4] www.nytimes.com/interactive/2019/04/30/opinion/privacy-targeted-advertising.html.
[5] Data providers claim the information stored and shared is anonymous, but that doesn't mean it remains that way. Specific facets of the data, and patterns within it, can learn to the identification of individuals.
[6] Shoshana Zuboff, *The Age of Surveillance Capitalism: The Fight for a Human Future at the New Frontier of Power* (PublicAffairs, 2019).

sensationalist headlines are like a last-ditch attempt to make oneself heard within the media noise. Once a theme becomes viral, it is taken up by everyone in a reactive cycle and drama-fueled feedback-loop. Editors break with the norms of classical journalism: In news programs, reports are accompanied by music and artificial moods are created through the use of slow motion. The former president of the German Bundestag, Wolfgang Thierse, put it aptly: "The talk shows are an essential part of the hysterical political communication in Germany. The focus not only on topicality, which is correct and understandable, but also on the aggravation in the title and in the moderation – fear, negative expectations, anxiety. That doesn't promote and alleviate anxiety and fear, that doesn't promote and fight populism."[7]

A study of the 141 German political talk shows in 2016, where German media constantly talked about refugees, showed that other relevant topics such as climate change or renewable energy concepts were not taken up in a single round.[8] However, now, only three years later, the climate debate is vigorously discussed across all forms of media following the global "Fridays for Future" protests.

The focus is no longer on content, but on attention. The guiding principles are not facts or social relevance, but reach, hit rates, and aggressive click-baiting.

11.5 WE UNDERESTIMATE THE EFFECT OF THIS EXCITATION BUSINESS ON OUR PERCEPTION

One well known example from science is the media coverage of animal experiments.[9] Emotions always win. The British market research company Ipsos MORI conducted a survey compromising 25,000 people from 33 countries in order to find out how the perceived reality of citizens differs from the actual facts in the country.[10] People in Germany, for example, estimated the percentage of migrants living in their own country to be twice as high as it actually was, whereas, in contrast, they underestimated the proportion of overweight people. When asked what proportion of children and young people under the age of fourteen were overweight, the answer was half that of the actual figure.

The open social networks are a tempting invitation to populists and conspiracy theorists. The Polish sociologist and philosopher Zygmunt Bauman describes this historical transformation process as *liquid modernity*:

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[7]   www1.wdr.de/daserste/monitor/sendungen/talkshows-102.html.
[8]   Ibid.
[9]   Tipu Aziz, John Stein and Ranga Yogeshwar, "Animal testing: TV or not TV?," Nature, volume 470, 457–459 (2011).
[10]   Ipsos MORI, Perils of Perception 2015; www.ipsos.com/ipsos-mori/en-uk/perils-perception-2015; Folien unter www.ipsos.com/sites/default/files/migrations/en-uk/files/Assets/Docs/Polls/ipsos-perils-of-perception-charts-2015.pdf. Ashley Kirk, "What are the world's most ignorant countries?", The Telegraph, 12 December, 2015; www.telegraph.co.uk/news/worldnews/12043708/What-are-the-worlds-most-ignorant-countries.html).

Social media do not promote our capacity for dialogue because it is so easy to avoid controversies . . . Most do not use the social media to promote community, not to broaden their horizons, but on the contrary to hide in a comfort zone where they only hear the echoes of their own voice, and where everything they see is reflections of their own faces.[11]

This shift in priorities leads to a decoupling between the media world and reality. The perceived truth is more important than actual facts; the perceived will of the voter wins, even if this is perhaps only a wish far away from reality. When politicians intend to put a topic on the agenda, its media effect is explored first. Subsequently, we observe how the political agenda is increasingly dictated primarily by its media impact and not by the necessity of its content. How dramatic this situation has become can be seen, for example, in the absurd buckling of the Japanese government in the context of cervical cancer vaccination. The media power of the Japanese vaccination opponents led to a decline in the vaccination coverage from 70 percent to less than 1 percent.[12]

11.6 "digitality" and reality start to mix

The appeal of the digital Eldorado lies in its latency-free response time, the complete dissolution of geographical distances, and its promise of abundance and augmented reality. Here, one moves from one impulse to another and the digital space turns out to be the breeding ground of a new world dynamic demanding constant innovations and surprises. This unprecedented attraction leads to a novel kind of global migration to a "digital continent." Some see this migration into the digital world as running away from reality; an escapism from a real world replete with shortcomings and threats. Our attitude toward our personal lives is increasingly determined by the digital world. It is not only communication and information gathering that are organized by search engines and platforms. The net is increasingly becoming the kernel of our lives and the cosmos of our dreams. The focus of our consciousness is shifting into the digital world where profiles are the emerging substitute for the actual human and likes are becoming a barometer for one's attitude to life.

The current German public television (ARD-ZDF) online study states in its 2018 report that the average daily Internet usage time of 14-year-olds and older has now grown to 196 minutes per day. In the younger age group of 14- to 29-year-olds, the average daily Internet usage is just under six hours.[13] In this group alone, the daily time for individual communication – chatting, emailing, WhatsApp or other messenger activities – adds up to 152 minutes.

[11] http://elpais.com/elpais/2017/01/10/inenglish/1484037730_759492.html.
[12] www.spektrum.de/news/impfgegner-gewinnen-in-japan-mit-falschmeldungen-und-fake-experimen ten/1635488.
[13] www.ard-zdf-onlinestudie.de/files/2018/ARD-ZDF-Onlinestudie_Infografik_2018.pdf.

As you are reading this sentence, over 200,000 Facebook posts and 22,800 new tweets are streaming online.[14] Facebook users watch one billion videos per day. Every second, 28,000 Instagram images are liked and on WhatsApp alone, more than 27 billion new messages are exchanged every day. These figures reflect the global intensity of this shift – no other medium has achieved such a high level of social penetration in such a short time.

In addition to communication, more and more processes are shifting from physical space to the digital universe: shopping, partner selection, booking travel, paying bills, and medical analyses, digital images of our reality are being created everywhere. This digital migration subsequently leads to changes in behavior, as "digitality" and reality mix. One example is the change in physicality: the portraits we see on Instagram or Facebook are often embellished by apps such as Facetune[15] which can smooth wrinkles and skin spots, retouch body shapes, and bleach teeth using algorithms. The posted images are thus beautified artefacts that unfold their normative power over time. Here, too, the flow direction is reversed: real people attempt to emulate and correspond to their digital alter egos. We want to look like digital avatars. Actresses eliminate their wrinkles, politicians straighten their teeth, and newscasters dye their hair, because the visual impression is becoming increasingly important. If we compare the political campaigning of the seventies with today's electoral campaigns, this change is obvious as the portraits of the candidates are now being retouched and smoothed in such a way that they look completely artificial. Here, a new culture of artefacts is established, which unconsciously extends to other areas as well.

While classical media still have to select their published content rigorously due to limited broadcasting space or newspaper pages, the digital world is free of these restrictions. The media space seems to be boundless and holds space for everything from potato cultivation, quantum physics, UFO sightings to political statements. Curation is almost completely eliminated, making the digital media space a gathering place for everything and everyone, superimposed by the dissolution of authenticity. Through the use of modern AI techniques, the production of "Deep Fakes" are now possible: artificial images and videos are already produced in such a perfect way that distinguishing between real and fake is almost impossible.

11.7 FAKE SCIENCE

The increasing use of the word "authentic" is ultimately a sign of this emerging culture of artificiality. Over time, we become accustomed to transforming reality to our taste. So why not also adjust the universe of scientific knowledge according to our needs? Tobacco companies present studies minimizing the risks of smoking in

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[14]   www.webfx.com/internet-real-time/ also: www.internetlivestats.com/watch/internet-users/.
[15]   www.facetuneapp.com.

pseudo-journals; pharmaceutical companies praise the effectiveness of their medicines; climate "experts" provide alternative explanations for global warming; and scientific institutes present a novel "dual-fluid reactor" that supposedly meets high safety standards as well as economic goals.[16] There are numerous specialist conferences, institutes, and purported experts whose publications and websites are characterized by the same patterns that are also used within "serious" science: they quote each other, use complicated technical terms, and list their merits. A genuine expert may notice the bluff, but to the layman there is no comprehensible difference and so what we experience is a questionable fusion of fake and real science.

In 2018, research by journalists from Westdeutscher Rundfunk, Norddeutscher Rundfunk, and Süddeutsche Zeitung (WDR, NDR, and SZ) revealed how dubious journals are diluting quality standards of scientific publications such as anonymous peer reviews.[17] Open access procedures and a large number of *predatory journals*, as the librarian Jeffrey Beall calls them, have changed the current fee model of scientific journalism.[18] Traditionally, readers financed printed journals through their subscriptions. With electronic publishing, an increasing number of journals are asking authors to pay and posting their articles on the Internet free of charge for the reader. The open access model has its advantages, because in principle it makes research accessible to everyone. Poorer nations in particular benefit from open access to up-to-date research. Most open access publications are no less trustworthy than the average of their printed predecessors, but a questionable business model has emerged from this reversal of the flow direction: In the life sciences alone, some 30,000 journals vie for paying authors. Under the general pressure to publish and the struggle for attention, junk journals are created that wave through the articles of their customers without serious peer reviewing. This system is fueled by additional drivers such as "impact factors."

There is a remarkable parallel between the media and science landscapes, because in both cases traditional structures are being replaced by corresponding digital publication models. Editorial rigor begins to fade out and, in both cases, underlying commercial criteria become the driving force. As a result, the citizen is wrapped in a fog of questionable information and not in a position to distinguish between the relevant and the irrelevant or to classify news-streams accordingly. While for a long time, the procurement of information was an important criterion for responsible participation, we are now confronted with an ocean of information such that sorting and classifying becomes the essential skill, instead of critical analysis. But how is this possible, in an environment where algorithms and commercial platforms are taking over?

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[16] https://festkoerper-kernphysik.de/dfr.
[17] www.ndr.de/nachrichten/investigation/Dossier-Das-Geschaeft-mit-der-Wissenschaft,fakesciencedossier100.html.
[18] www.zeit.de/2017/11/fachzeitschriften-fake-forschung-wissenschaft-betrug-publikationen/komplettansicht.

On the occasion of the 70th anniversary of the Universal Declaration of Human Rights, UNESCO expressed a desire to reaffirm its commitment, mandate, and role in the promotion and protection of human rights, but when the authors of the former declaration spoke of the merits of scientific progress in 1948, there was probably still more of a consensus on what it meant. In today's world, the term has become blurred and one would almost have to ask whether universal declarations still matter, as our frames of orientation seem to have changed. Large political parties are dissolving, classical leading media are on the retreat, privacy is being commercialized. The balance between public and privately financed research has shifted and the border between the two has become blurred.

The application of intelligent commercial algorithms leads to a social de-solidarization effect. Within the insurance industry, for example, behavioral policy pricing models have been introduced. The former "we" is shifting to "I" and fragmented societies are beginning to lose their common denominator.

11.8 WE UNDERESTIMATE THE EFFECT OF COMPLEXITY

Thus far, many science communicators – including myself – have been convinced that scientific literacy would automatically lead to more responsible decision-making among citizens. However, we seem to have underestimated the impact of growing complexity.

Medicine, for example, so essential to our continued health, is becoming inscrutable for most people, but so are the worlds of technology, the media, and finance. The virus of complexity has spread everywhere. No politician truly understands the details of a free trade agreement and bankers are ignorant about nonlinear derivative algorithms. Car mechanics no longer diagnose what is wrong with a car by the sound its engine makes, but instead connect its internal systems to a computerized interface. Complexity has taken on such proportions that even the most everyday items are beyond our understanding. What is hidden under the smooth user interfaces of our touchscreens is far beyond our ken. When we proclaim the necessity of public understanding of science, we ignore the simple fact that the inherent complexity of science in the modern world makes this level of widespread understanding impossible.

In our technological world of wonders, we have to trust computer scientists, chemists, climate researchers, and medical professionals. Every farmer fertilizes his fields in total ignorance of the deeper mechanisms of the expensive granulates and pellets he distributes. He, who ploughs the same soil as his fathers and grandfathers once did, suddenly falters, confronted with the incomprehensibility of his surroundings. For most people, the explosion of knowledge and innovation is felt like an act of incapacitation. Progress pushes them out of their comfort zones into a world that is deeply unfamiliar. Uncertainty and mistrust spread, and the gleam of the Enlightenment is dimming. Some desire a simple world backed by clear answers

and, in their voices, we can perceive the fear-driven anger of incomprehension. They fight against their incapacitation, terrified that the future will snatch their world from them. The former rulers of the clear and comprehensible are now the slaves of complexity, the guardians of tradition have become the driven ones of a disruptive progress. The phenomenal changes wrought by science and technology have generated a growing posture of resistance within societies. Suddenly, the voices of doubters, climate sceptics and vaccination opponents increase. People yearn for simple answers and in a complex world they will believe those who promise simplicity and plausible pseudo-rationality above those who tend towards a more complex explanation even if that is the truth.

11.9 HOW TRUSTWORTHY IS SCIENCE?

When researchers examined the immune system of bacteria a few years ago, they came across strange, repetitive gene sequences. Over time, it became understood that similar structures existed in the genomes of many different prokaryotes, and gradually researchers began to understand how bacteria, for example, protect themselves against viral infections. But then it became clear that this system, known as CRISPR-Cas, also poses a revolutionary and simple method for gene modification.[19] And with this promising potential application, the entire branch of research was poisoned overnight by economic incentives. The ongoing patent dispute over CRISPR between the Broad Institute of MIT and Harvard, UC Berkeley, and other players is a shameful example of how the scientific joy of a promising discovery can quickly lead to a bitter battle for economic exploitability. Now, attorneys, patent judges, and venture capitalists run wild with a scepter snatched from scientists.

Similar observations can also be made in other disciplines. Recently, the *New York Times* published an illuminating article about the salaries of researchers in the field of artificial intelligence research.[20] At Google DeepMind in London, for example, the annual personnel cost for 400 employees amounted to USD 138 million in 2016. That is an average salary of $345,000 per employee. Consequence: Outstanding scientists leave public research institutes and universities in order to enter the service of large and well-paid private companies. These salaries siphon talent from the well of expertise that would normally feed independent, public institutions and universities. Independent expertise is lacking from discourses considering the medium- and long-term impacts of social networks and artificial intelligence. The questioning of Marc Zuckerberg by the US Congress in 2018 was a demonstration of political ignorance in the field of social media. The questions asked revealed a shameful paucity of knowledge about a fundamental influencer of global society and a relevant and necessary debate on the application of

[19] Martin Jinek et al., "A Programmable Dual-RNA-Guided DNA Endonuclease in Adaptive Bacterial Immunity," Science 337, Issue 6096: S. 816–82 (2012).

[20] www.nytimes.com/2018/04/19/technology/artificial-intelligence-salaries-openai.html.

basic democratic principles to social media platforms was ultimately derailed due to a lack of independent competence.

It is time for science, with confidence and passion, to set a counterpoint to one-dimensional economic perspectives. Scientists must insist that their findings serve the common good. If algorithms increasingly destabilize our financial world, or perpetrate inequality and discrimination, then it is for the scientific community to critically question their conduct and permissiveness and rethink the consequences of their actions. If the findings of the psychology and neuroscience disciplines are irresponsibly misused by companies for the manipulative targeting of voters, as in the case of Cambridge Analytica, then we ought to hear a clear voice of dissent and opposition from the ranks of scientific professionals and researchers. But where, within computer science, do we hear critical discussions about algorithms or the growing evaluation of big data? In these fields, it is critical that risks are examined by coalitions with interdisciplinary expertise and a social perspective.

We urgently need more reflected progress. In some areas we are confronted with questions of dual use and unfortunately, there are not only "benefits of scientific progress and its applications."[21] In the dawn of a new arms race, scientists could simply refuse to engage in any further research on autonomous weapons. Data scientists could question the goals of the commercial data collection frenzy, even if these questions could lead to restrictions within their own discipline. With the growing impact of science on all areas of our lives, societies must critically question the benefits and the objectives of scientific research. When science speaks of the "public understanding" of its disciplines, we should not conflate this with "public acceptance." The right for everyone to enjoy the benefits of scientific progress and its application contains within its normative framework a right to clearly define wherein those true benefits lie.

11.10 DOES SCIENCE REALLY WANT CRITICAL DIALOGUE AND IF SO, WHAT IS IT PREPARED TO DO ABOUT IT?

When research budgets are cut or funding falters, science likes to raise its voice. In June 2018, German astronaut Alexander Gerst started his mission on the International Space Station (ISS) and during each press event, the strictly "scientific" nature of his mission was repeatedly stressed. Here, "scientific knowledge" was used as an excuse, although there was no reliable basis for it.

Interestingly, criticism of space research is missing from the scientific world. But how different things are when people's own research budgets are up for grabs. This was the case in 1990, for example, when the Federal Republic of Germany's opulent space budget led to savings having to be made in other fields of research. Suddenly, there was an outcry: in November 1990, the German Physical Society published

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[21]   www.ohchr.org/EN/ProfessionalInterest/Pages/CESCR.aspx.

a sharp criticism of the benefits of manned space flight. At that time, there was a whole catalogue of plausible arguments against the promotion of expensive manned space flight. But was the underlying motive really a reasonable, critical discussion about the benefits of manned space flight? Did people want to set the priorities for funding according to scientific criteria in an advisory capacity? Or was it merely a matter of securing their own benefits? In the meantime, the physicists probably have enough money, and although the factual arguments against expensive manned space travel from that time are still valid, the critical voices seem to have faded. Thus, astronaut Alexander Gerst floated off on his "scientific" mission without any counterarguments.

If scientists want to argue credibly, they must demonstrate a degree of balance and rigor. They must take the floor to debate critically – also when their own interests are not the only consideration. Scientists ought to consider the misuse of the product of their own research a reason to raise their voices. Scientific knowledge shapes our technical progress, but its direction is currently set by private interests that do not always coincide with the interests of societies as a whole, and this is precisely where we need our scientific professionals to find the courage of their convictions.

The majority of digital innovations in Silicon Valley are based on lucrative business models. If these fail to materialize, usually no research will be conducted. However, there are some exceptions: In the early 1990s, Tim Berners-Lee invented the World Wide Web at the European research center CERN. On April 30, 1993, the directors of CERN declared that the technology should be freely available to everyone, without any patent claims.[22] Without this remarkable openness, marked by a decisive focus on sharing knowledge and foregoing profit, the overwhelming growth of the Internet may never have been possible.

Scientists ought not to orient themselves towards the market, but instead position themselves to offer the reasonable and independent guidance now much needed by an insecure society. This important dialogue between science and society, however, also requires appropriate financial support. So far, the scientific community has seemed disinclined to do so, apart from a handful of initiatives and projects whose paltry funding is at best measured alongside the purchase price of a somewhat more expensive piece of laboratory equipment.

11.11 COMMUNICATION WITH CITIZENS HAS PLAYED A SUBORDINATE ROLE IN SCIENCE SO FAR

Although there are good initiatives and some notable individual efforts, there is still a general lack of systematic dialogue focused on reliable processes for scientists and citizens jointly to discuss critical issues, even though they seem to have common goals. The Science Barometer 2018, a representative survey of science organizations in Germany, shows that for three-quarters of the respondents, consideration for the

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[22]   https://home.cern/science/computing/birth-web.

common good is among the most important qualities that a good scientist must possess. However, less than half of those surveyed (40 percent), believe that scientists actually work for the good of society.[23] According to the respondents, the principal explanation for distrust of modern science is its dependence on financial backers. Furthermore, more than two thirds of the respondents felt that the influence of industry on science was too great. If, in this context, we demand the right of all people to benefit from the advantages of scientific progress and its applications, then it is not only the ability of science to communicate and engage in dialogue that is of central importance, but also its independence.

Until now, young scientists have completed their studies without any obligatory education on the importance of, and techniques for, communication with lay people. There are no academic credits for the kind of dialogue with the public, which is frequently demanded of them. Education of new scientists simply does not focus on these issues. As a science journalist, I have spoken out for many years in favour of opening up science and, over the past twenty years, numerous initiatives have been launched in Germany. Since 2000, the *Communicator Prize* has been awarded to scientists in Germany who have rendered outstanding services to communicating their work or scientific issues in general to the public.[24] The prize was intended to encourage scientists to engage more extensively in dialogue beyond their own community. The vast majority of scientists are unknown to those who benefit from their work and rarely enter the public arena. This applies equally to young talents who now shine in scientific circles. Even wonderful public lectures by scientists ask too much of the lay person and are often aimed at the science community and not at the general public. Scientists are too rarely seen on political talk shows, for example, and thus still lack a formative impact on broad cross-sections of the population. As a science journalist, over the course of thirty years, I have had to learn how difficult it is for most scientists to communicate with the general public. Most scientists, when interviewed, fail to break down their exciting research in comprehensible words or to explain complex concepts in terms intelligible to the lay person. A developmental biologist, who was a Nobel Prize winner, was once asked by students during a public event whether it was possible to revive dinosaurs, as in the film Jurassic Park. She looked at the student and asked what Jurassic Park was.[25]

11.12 BOTTOM UP

In the summer of 2004, twenty-eight-year-old Salman Khan helped his cousin Nadia[26] who lived in New Orleans and had problems understanding mathematics. Salman

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[23]   www.wissenschaft-im-dialog.de/projekte/wissenschaftsbarometer/wissenschaftsbarometer-2018/.
[24]   www.dfg.de/gefoerderte_projekte/wissenschaftliche_preise/communicator-preis/index.jsp.
[25]   www.wissenschaft.de/allgemein/das-leben-zwischen-gott-und-genen/.
[26]   Bryant Urstadt: "Salman Khan: The Messiah of Math", Bloomberg Businessweek, 19 May, 2011; www
       .bloomberg.com/news/articles/2011–05-19/salman-khan-the-messiah-of-math.

Kahn, who had recently completed his master's degree in computer science and electrical engineering at MIT and worked for the hedge fund Wohl Capital Management in Boston, designed a small website for his cousin. Nadia was then able to enjoy a special tutoring course despite a distance of more than two thousand kilometers. Salman has a great didactic talent. Using a simple messenger program, he first produced small online sequences with explanations and tasks for Nadia. He calmly taught her how to calculate fractions, guided her through the murky depths of the search for the lowest common denominator, and explained little tricks for shortening fractions and the secret of prime factor decomposition.[27]

As Nadia's performance dramatically improved, her younger brothers Arman and Ali also followed their cousin's online tutorials. Sal Khan expanded his website, bought a tablet and turned the screen into a lively blackboard where he gradually explained the mathematics curriculum to a growing crowd of students. He posted his first video on the internet on November 16, 2006. When he realized just how many people were avidly watching his lessons, he quit his job and created an informative world of online tutorials. Ten million students worldwide now use his free tutoring and can access over three thousand videos on the website of the Khan Academy. Yet Khan and his team continue to develop their learning platform. Personalized learning plans with tasks and tests make completely individual learning possible. In contrast to rigid, frontal teaching, the learning pace of the individual is also considered. Khan proved that even weak students can significantly improve their performance through the tutorials.

The Khan Academy is now one of the most successful free online learning platforms in the world.[28] Influential individuals like Bill Gates, as well as many well-known multinationals, have supported the expansion of Khan's online school with generous donations. With its staff of programmers, teachers, and data analysts still growing, every lesson is evaluated and optimized. This lively site represents a revolution in the education system. In addition, there is now an abundance of excellent YouTube channels that explain scientific connections in accessible and clear ways, often beautifully, artfully, and engagingly. Grant Sanderson's outstanding mathematics blog on YouTube, "3blue1brown," is an excellent example.[29] While communication within institutional science is progressing slowly, individual talents on the Internet have uploaded or established great tutorial systems. Some of these sites have several million subscribers and demonstrate the potential for good science education.

In 2012, Harvard and MIT founded the online platform edX.[30] A MOOC (Massive Open Online Course), it combines lecture videos with reading materials and open

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[27] www.khanacademy.org/math/pre-algebra/pre-algebra-factors-multiples/pre-algebra-prime-factorization-prealg/v/prime-factorization.
[28] www.khanacademy.org.
[29] www.youtube.com/channel/UCYO_jab_esuFRV4b17AJtAw/channels.
[30] www.edx.org.

forums in which learners can exchange ideas. In the first year of edX, 155,000 students enrolled, more than have enrolled at MIT itself in the university's 150-year history. Renowned universities are contributing to the platform in greater numbers: The University of California, Berkeley, for example, as well as the TU Delft, the Sorbonne in Paris, the ETH Zurich and the RWTH Aachen.

The curriculum of edX covers over 1,300 courses and, in the virtual classrooms, students from as disparate places as Brazil, the United States, India, and South Korea exchange knowledge, form study groups, and discuss teaching materials in Skype conferences. In this the largest virtual university in human history, world-renowned experts teach. Online education is now global and tens of thousands of students from every continent take part in a single virtual course on genetics, macroeconomics, or the history of the 1854 London cholera epidemic. For developing countries in particular, platforms like edX offer tremendous opportunities as they enable poorer students to gain access to education that might otherwise be beyond their reach. Other virtual universities have emerged, such as Coursera, Udacity, and NovoEd, and it is inevitable that many more will follow.

11.13 A NEW SCIENTIFIC SELF-IMAGE

Although the teaching of science has improved considerably over the years, a resilient and professional dialogue is still missing when it comes to the goals of research, for example, or to ethical aspects of the research itself or its uses, or to questioning scientific progress in a broader, social context. In a world characterized by wide, fast-paced, and dramatic change, science must learn to deal with the social consequences of its actions much more intensively than in the past. Ethical questions and the meaningfulness of progress will come to play an increasingly important role. The same can be said of the independence of science from economic demands. This presents an opportunity, because citizens are increasingly looking for orientation and science should be the way in which they find that orientation. Open, professional communication between science and the public should become part of a new scientific self-image.