

Reinhold Leinfelder Alexandra Hamann Jens Kirstein Marc Schleunitz (Eds.)

SCIENCE MEETS COMICS

Proceedings of the Symposium on
Communicating and Designing the Future of Food
in the Anthropocene



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Stephan Packard • Lukas Plank • Nick Sousanis • Katerina Teaiwa • Arnold van Huis

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Ein interdisziplinäres Labor



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Berlin

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Introduction to the Symposium Proceedings

In October 2015, the Cluster of Excellence *Image Knowledge Gestaltung. An Interdisciplinary Laboratory* at Humboldt Universität zu Berlin staged a symposium entitled *Science meets Comics*. Academics from various disciplines converged along with artists from all over the world in order to discuss the future of global nutrition – and the medium of the comic strip as a communication tool for the complex issues in this field. The open two-day symposium was followed by a closed, three-day workshop wherein the artists and cluster members took up the issues raised at the symposium and worked on possible directions for the future.

How did this somewhat unusual meeting come about? To answer this question, we must look back to 2013 and the inception of the cluster. The Cluster of Excellence assembled 25 different research disciplines from the areas of Gestaltung and science – natural, cultural, and social as well as the humanities. This combination of disciplines allows relationships to germinate that would unfold in new perspectives on the objects and processes of our times. The laboratory created a forum for academic work that previous rigid disciplinary limits and institutional barriers had precluded; until then, universities were, for the most part, organised in disciplinary departments and faculties. The aim of the cluster was, and is, to discover possible synergies through new collaborative methods and interlinked interdisciplinary (i.e. not simply multidisciplinary) research approaches; it aims to unearth their potential and consolidate knowledge gains with the help of the subjects more readily associated with Gestaltung.

One of the cluster base projects, *The Anthropocene Kitchen: A laboratory connecting home and world*, was part of the Interdisciplinary Laboratory. We (the editors, together with other project scientists) investigated the kitchen as an influential locus for the exchange of energy in the 'Anthropocene' age – our current geological era, the era of humankind. Our focus was the kitchen as one of the most energy- and resource-intensive loci, the terminal of a global production chain and logistics systems, through whose daily practices – native or general – the Anthropocene takes shape. Two levels of observation and measurement were involved and interlinked: on the one hand, the cultural level of preparing and eating food; on the other, the level of natural science, where resources, energy, and material flows are itemised on the balance sheet. The overriding aim was to highlight the fact that the Gestaltung

of everyday life itself requires the contemporisation of global chains of effect which involve individual actions and a consideration of outsourcing practices that have persisted until now. The topic of food, which affects everyone in equal measure, is a perfect candidate in this endeavour.

Ten experts from the fields of geology, biology, geo-ecology, architecture, design, and geo-informatics worked on the base project, concentrating on themes that had augmented over the years and setting out to find solutions for the future of the global food supply. A conscious decision was taken to select diverse forms of publication.

Our group, with a focus on global resource flows and a working title of 'Welt' (world), decided to take the comic as a communicative medium of Gestaltung. The possibilities it provided for combining word and image gave us the necessary means to represent complex contexts in a visual and appealing way, without having to simplify things. The use of narrative and personalisation can moreover convey factual information along diverse channels of perception. The embedding of facts within a narrative seems more than necessary, particularly at a time frequently described as 'post-factual'. This interlacing is especially evident in the cultural and artistic diversity of the comic which was implemented by 12 international graphic artists. A further emotional level of meaning transpired through this project, which could not have been carried by words alone.

However, the production of a factual comic strip has one more objective, as yet too seldom countenanced: In order to make social dynamics and processes apprehensible and researchable in a societal context, one needs to remove the distinction between 'producing scientific knowledge' and the 'communication of science'. These two areas are particularly closely linked in the field of food and nutrition by acquired know-how, itself strongly influenced by culture. The narrative of each chapter was developed from interviews with people from ten different countries on the subjects of food habits and eating cultures. We took this dialogue-driven 'co-design' as a basis for generating the subsequent scientific research need. We did not attempt to formulate hypotheses in advance, in order to then seek empirical backing through interviews; instead, we let our research be directed by the protagonists' answers. Consequently, some unexpected re-combinations, linkages, and new evaluations in our scientific work arose out of that process.

In order to attain the necessary transdisciplinarity, particularly the involvement of society and thus the fusion of knowledge generation and transfer, we deliberately

kept the development of the storyboard relatively open, having first defined a few conditions to the structural framework. This required the theme of nutrition be discussed and tested against potential and possibly expandable options for the future, focusing on three main elements: 1) materials flows (local, regional, and global), 2) infrastructures (transport routes, markets, the home, and especially, the kitchen), and 3) the greatest possible diversity of cultural contexts. This was presented by means of a 'journey' through various countries. We did not address the three elements in a standard progression but adapted them to the storyboard as drafted together with the protagonists. This was because many aspects crystallised only after an intensive exchange of ideas.

The main part of the comic provide an outline – one might also say an exemplary mapping of the food behaviours in today's Anthropocene era – and thus of the cultural preferences of the protagonists and the resulting outcomes for local, regional and global environments, and the entire earth system. The last chapter on the future of global nutrition was, as mentioned above, undertaken by all the artists involved in the book at the workshop (read more about the content of the book in the epilogue on page 111-117).

This much on the background. Now, to return to the symposium, which the present volume seeks to document. The first day of the symposium was dedicated to comics studies. Following the welcome speech by Reinhold Leinfelder, Principal Investigator for the project, comics studies scholar Jaqueline Berndt, back then still at Kyoto Seika University, surveyed science manga with a special focus on nutrition and food safety after the Triple Disaster of Fukushima on 11 March 2011. Nick Sousanis, assistant professor of the School of Humanities and Liberal Studies at San Francisco State University, US, who published his doctoral thesis entirely in comics, spoke about the educational potential inherent in the interweaving of image and text. Science journalist Lukas Plank from Vienna invited people to discuss whether scientific cartoon strips should be subjected to rules and guidelines in order to make sources and facts more transparent. Stephan Packard, a researcher into media culture at Albert-Ludwigs-Universität Freiburg and President of the German Society for Comics Studies (ComFor), developed this theme further by asking "How factual are factual comics?". This was followed by a presentation by illustrator Veronika Mischitz and Henning Krause, of the Helmholtz Society's science communication department, of excerpts of their monthly web cartoon strip *Klar soweit? (Savvy?)*. Finally, Reinhold Leinfelder explained the background for the *Eating Anthropocene* comic as a format for intercultural, cross-discipline, and participative communication.

The second day was dedicated to the subject of nutrition. It was introduced by Arnold van Huis, Emeritus Professor at Wageningen University, Netherlands, a leading expert on insects as animal feed and human food. He expounded the potential of insects as an alternative source of animal protein, both for human consumption and for feeding animals. Cultural scientist Katerina Teaiwa of the Australian National University in Canberra joined the symposium by Skype and talked about the environmental effects of phosphate mining on Banaba, a tiny island in the middle of the Pacific Ocean. She also discussed the social and political effects of mining on the population of Banaba in order to provide for rich harvests in the agricultural fields of Australia and New Zealand. Anne-Kathrin Kuhlemann, Managing Partner of BE Solutions & Blue Systems Design GmbH, spoke about the economic chances of sustainable and modern cycles of food production specifically in urban settings, citing as an example TopFarmers in Berlin.

The agricultural and nutritional scientist Toni Meier of the Martin Luther University Halle-Wittenberg, Germany, provided the audience with a lot of theoretical and practical input at the 'Lunchtalk' with reference to the environmental footprint of various foods and diets. This was accompanied by a chickpea stew – a dish with a very tiny ecological footprint. As dessert we served a bee sting cake with drone larvae, made to a recipe featured in the comic.

This volume of symposium proceedings contains contributions from all the participants in a variety of formats including essays, lectures, comics, and an interview. We hope that this blend will foster the promising cooperation between science and the humanities by using the medium comic.

Reinhold Leinfelder, Alexandra Hamann, Jens Kirstein,
Marc Schleunitz, Theresa Habermann

Photo next page top: Lunchtalk at the second day of the symposium

Photo next page below: Artists of the comic *Eating Anthropocene* and members of the Cluster of Excellence. From left to right: Ulrich Scheel, Anne Schmidt, Ruohan Wang, Stephan Barthel, Joëlle Ebongue, Alexandra Hamann, Daniela Harsan, Sophie Goldstein, Samuel Jaramillo, Maki Shimizu, Martin Ernsten, José Aguiar, Marc Schleunitz, Zineb Benjelloun, Sarnath Banerjee



Photo by Jens Kirstein



Comics meet Science





Nick Sousanis is Assistant Professor at San Francisco State University. His graphic novel *Unflattening* from Harvard University Press, originally his doctoral dissertation, received the Lynd Ward Prize for Best Graphic Novel of 2015 and the 2016 American Publishers Awards for Professional and Scholarly Excellence in the Humanities.

More at www.spinweaveandcut.com

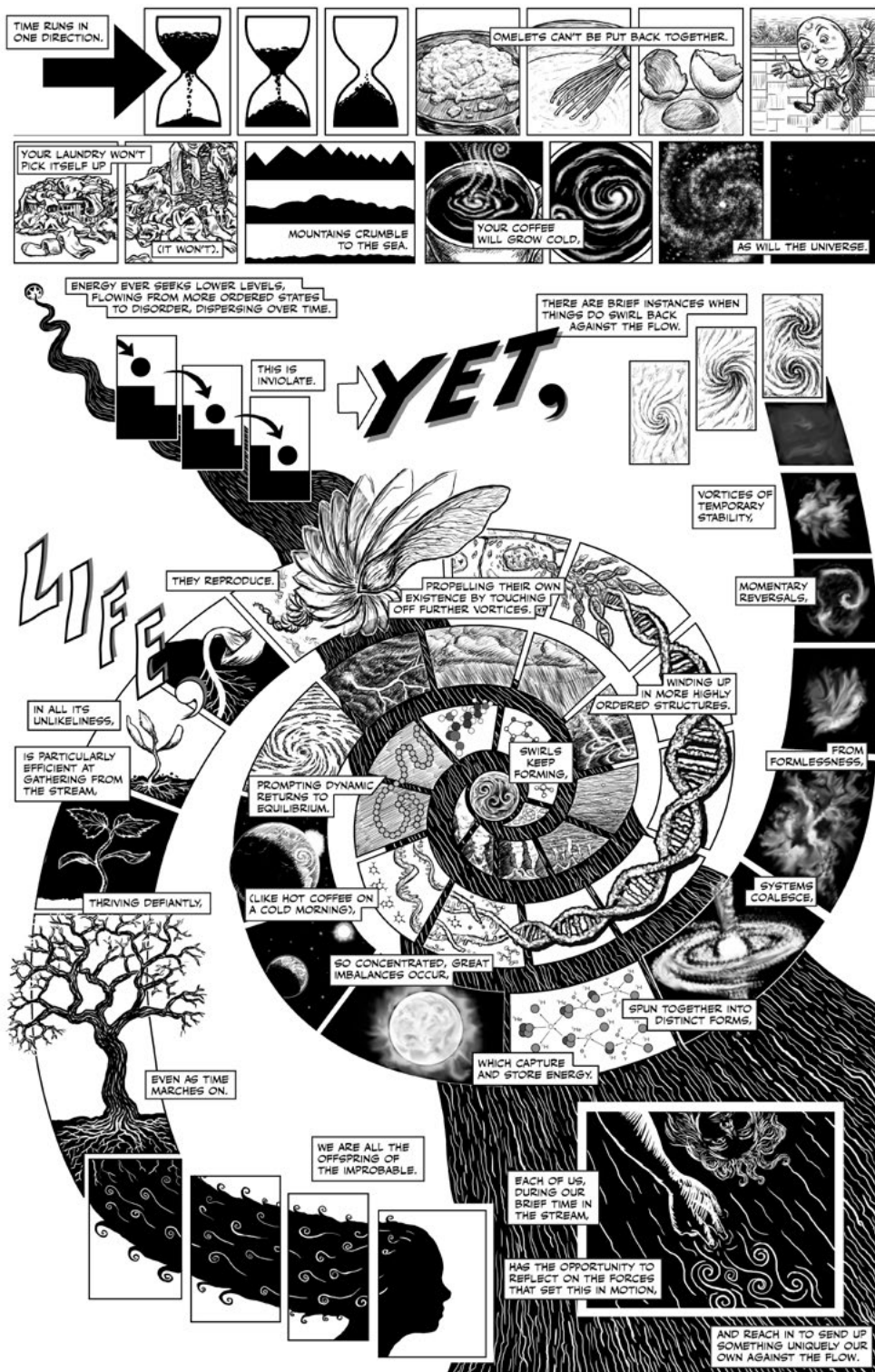
Nick Sousanis

Beyond Illustration

Sophisticated science reported on in comics. The once unthinkable is here as comics are being leveraged and enthusiastically welcomed into forums that would have been off limits not long ago. It's an exciting time of change. But in this headlong dash forward, I want to offer a pause for consideration, and suggest that we ask, what are the things that comics do uniquely compared to other forms of representation? And from there, let us explore how we can best take advantage of comics' particular affordances to do with comics things only comics can do.

The most common approaches to informational comics often come filled with talking heads, visible narrators, something familiar to explain (in words) something less so. It's perhaps not all that different than what has come before, only dressed up in pictures. But is this the only way forward? Can we move past more narrowly conceived notions of explanatory narratives to imagine comics that thrive in the visual, and do less telling, and more showing? (This is not necessarily a call for fewer words, rather a deep consideration of how text is incorporated into the visual ecosystem that is the comics page.)

I see in this nascent moment for comics, an opportunity to expand the possibilities going forward and experiment with just what a comic can be. Key to this is recognizing that making science and other complex subject matter into comics is not a simple matter of translation: adding illustrations to existing text. Rather, this is a different kind of thinking altogether, one necessarily immersed in the visual from the ground up. As the cartoonist Seth I think quite correctly observed, comics are less a combination of prose and illustration, but instead better thought of as a blending of poetry and graphic design. This kind of spatialized thinking that defines comics is particularly well-suited to wrestle with complex and abstract concepts, where their capacity to simultaneously present multiple perspectives can be used to bring great depth to our investigations far exceeding the apparent limitations of their static form. From drawing styles to vastly different methods of blending image and text (and certainly no text at all), comics encompass a broad range of approaches – and informational comics should be just as widely situated throughout that diverse environment. Even as we look inward at contemporary and past comics masters as models to borrow from, we can also leap outward beyond even the usual suspects of film and literature, and find inspiration from designers, those working in data visualization, and more to create new approaches on the page.



Excerpt from Sousanis, N. (2015): *Unflattering*. Harvard University Press, Cambridge, Massachusetts

Making complex subject matter accessible is only part of comics' potential. The very process of creating comics offers a powerful way for conducting research itself. Working between image, text, and composition in the multimodal fashion that comics allow opens us to the making of unforeseen connections. And this is an important outlet and reason to make comics even for those whose final output will ultimately end up being something more traditional. For me, that synergy between my art practice and research investigation – with each propelling the other forward – makes for a truly generative space where the work thrives and takes me in unanticipated directions.

Words can prohibit understanding, restricting access to those not already in the know with jargon and technical terms. I believe that if we can circumvent this language barrier, we can bring difficult concepts within reach for all. Thus my approach (and please keep in mind that this is insight into my particular approach, and that I am not suggesting that this is suitable for anyone else – except as a provocation to consider their own ways of operating) has been to get at the material through metaphor in both words and images. And in doing so, I'm allowing readers to make their own connections and find their own paths into the material. For those already well-versed, the work functions on another level as well. In addition to the metaphorical, I'm increasingly concerned with the spatial organization of the whole page. The bulk of my process is devoted to iterating in the sketch phase to explore ways to embody the idea through the composition itself and not only in the individual images. This gives each page a distinctly different identity in terms of its visual schema and structure.

Let me share a bit more specifically through two specific examples. First, a single-page comic I did for the *Boston Globe* on entropy. I gathered an enormous amount of research: common sense notions of entropy, traditional and contemporary physics, a poem by Robert Frost, biology, even economics theory, and more, sifting through it all for my comprehension in order to organize and discuss it in such a way that the concepts were sufficiently brought out, but not impenetrable. The demands of the composition shaped what was included and how the narrative unfolded, as it shifted from the linear to something that challenges traditional reading flow – in parallel with the very flow back upstream being discussed. In addition to all the reading, I also gathered massive amounts of visual references. Even for images essentially in the background and not directly referenced, I still want it to be accurate, to point to a particular kind of thing – not a generalization of a thing. This no doubt doesn't matter to a majority of readers, but there are those who will know if it's wrong (myself included) and it's worth the effort.

ALARMED BY THE GROWING PROBLEM, THE UNITED NATIONS CREATED THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC) IN 1988 TO ASSESS THE ISSUE.

ipcc



AT THE IPCC'S FIRST MEETING, THE DIRECTOR OF THE UNITED NATIONS ENVIRONMENT PROGRAMME, MOSTAFA TOLBA, IMPLORDED SCIENTISTS TO USE THE TIME LEFT IN THE CENTURY - JUST 4,000 DAYS - TO DEAL WITH CLIMATE CHANGE.

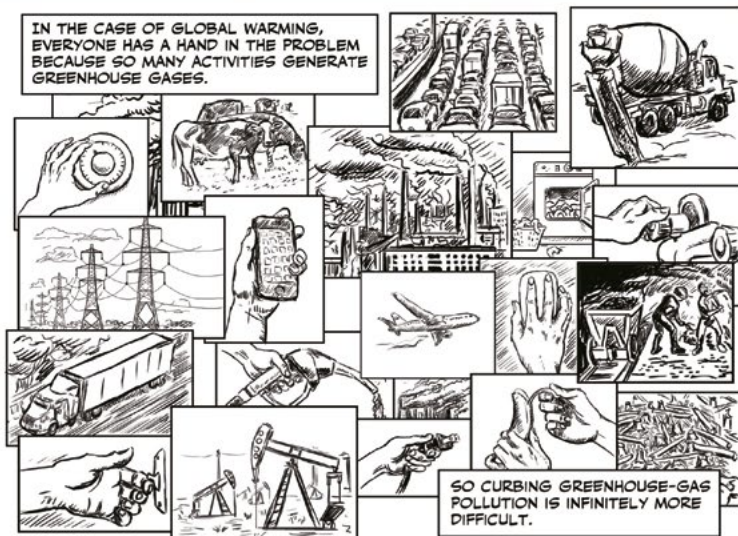
HOPES WERE HIGH BECAUSE THE WORLD HAD ALREADY TAKEN STEPS TO SOLVE ONE ENVIRONMENTAL DISASTER.



IN 1987, NATIONS ADOPTED A TREATY TO PROTECT THE OZONE LAYER.

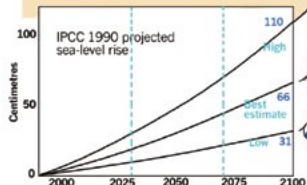
BUT REACHING THAT AGREEMENT WAS RELATIVELY EASY BECAUSE ONLY A HANDFUL OF COMPANIES IN A FEW COUNTRIES PRODUCED OZONE-DESTROYING COMPOUNDS.

IN THE CASE OF GLOBAL WARMING, EVERYONE HAS A HAND IN THE PROBLEM BECAUSE SO MANY ACTIVITIES GENERATE GREENHOUSE GASES.



SO CURBING GREENHOUSE-GAS POLLUTION IS INFINITELY MORE DIFFICULT.

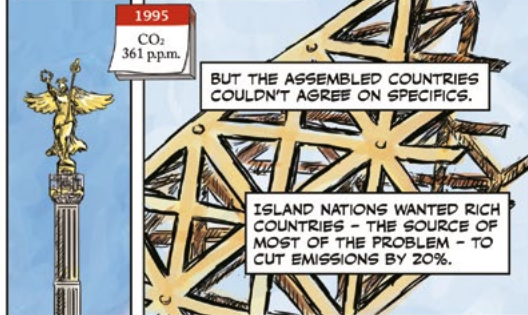
IN ITS FIRST REPORT, THE IPCC FORECASTED THAT IF CURRENT TRENDS CONTINUE UNTIL 2100, THE WORLD WOULD BE 4°C WARMER THAN IT WAS IN 1850. SWELLING OCEANS WOULD BE A MAJOR PROBLEM ...



...BECAUSE HALF OF HUMANITY INHABITS COASTAL REGIONS.

A MONSTROUS CYCLONE DROVE THAT POINT HOME IN 1991 WHEN IT KILLED MORE THAN 140,000 PEOPLE IN BANGLADESH.

THE RIO TREATY WAS CLEARLY NOT ENOUGH, SO NATIONS GATHERED IN 1995 IN BERLIN TO NEGOTIATE A STRONGER ACCORD.



1995
CO₂
361 ppm.

BUT THE ASSEMBLED COUNTRIES COULDN'T AGREE ON SPECIFICS.

ISLAND NATIONS WANTED RICH COUNTRIES - THE SOURCE OF MOST OF THE PROBLEM - TO CUT EMISSIONS BY 20%.

THE US DEMANDED THAT DEVELOPING NATIONS AGREE TO FUTURE COMMITMENTS.



CHINA SAID DEVELOPED NATIONS HAD TO ACT FIRST BECAUSE THEY HAD CAUSED THE PROBLEM.

DURING ALL-NIGHT NEGOTIATIONS, GERMANY'S ENVIRONMENT MINISTER, ANGELA MERKEL, BROKERED A DEAL. COUNTRIES WOULD HAVE TWO YEARS TO AGREE ON EMISSIONS LIMITS FOR DEVELOPED NATIONS.

The second example was a collaborative effort in which the journal *Nature* invited me to create a comic on climate change and the history of climate meetings, in conjunction with the 2015 Paris climate talks. On the first call with editorial and my science journalist co-author, I was insistent that drawing people sitting at meetings (unless key activities happened there that we would delve into) and depicting either my co-author or myself as visible narrators was the wrong way to go about this. I wasn't sure what I would do, but I felt strongly about those ground rules being established from the outset. If we were just going to talk about it, why bother making a comic? This required a shift of mindset, as they had anticipated more straightforwardly handing me text to which I would then add pictures. Balancing the journalistic demands, accurately presenting the totality of the history and science while still making a readable comic, was a terrific challenge – but that's that this work is all about. Our goals, as I see them, are to inform and bring people into these important conversations. This is not something to achieve by dumbing the work down, rather through the much more difficult work of making the concepts real, tangible, meaningful, and relatable. We strive to make good comics that make for an engaging and educational reading experience. With the stakes so great for our future, there is a deep need to effectively convey the complex issues we face. Comics have an extremely important role to play in communicating them, and I look forward to the inventive and varied approaches to come.



Stephan Packard is Junior Professor for Media Culture Studies at Freiburg University. His research interests include semiotic and psychoanalytic research into new and traditional media, the semiotics of affect, censorship and other forms of media control, as well as comics studies. He is President of the German Society for Comics Studies (ComFor), chief editor of the open access journal *Mediale Kontrolle unter Beobachtung*, and co-editor of the journal *Medienobservationen*.

Stephan Packard

How Factual are Factual Comics? Parasitic Imaginations in Referential Cartoons

There is no doubt that factual discourse exists in comics – the kind of communication that intends to be understood as a reference to a shared and actual reality. Factual comics are not, however, common. While the formal structure of comics clearly allows for factuality, the historical specificity of its aesthetics seems to introduce a non-binding but plausible *drift* of the art form, ultimately pulling away from reality and towards fiction. This does not prevent factual comics, but it allows for subversive remnants in their aesthetic make-up. One of these is a *parasitic imagination*, which might be understood in the context of Michel Serres' concepts of the parasite. It opens up cartoonish depictions for tertiary significations beyond the drawing and its ultimate real reference. Rather than avoid this basic vehicle of comic book discourse, the *challenge to factual comics* must be how to employ them in the service of the intended communication.

Fictional Drift

One of the most commonplace arguments in the recently growing field of comics studies is the (no doubt well-grounded) insistence that comics can be adult, serious, aesthetically advanced, and – factual. Haven't you seen Spiegelman's *MAUS*? Joe Sacco's *Palestine* is serious journalism! McCloud's comics on comics are scholarship, so comics can be scholarship too! And of course, Hamann's, Zea-Schmidt's, and Leinfelder's *The Great Transformation* conveys detailed scientific information about climate change alongside an earnest political appeal. All of this is 'factual' in the strict sense of a theory of fictionality and factuality (cf. e.g. Schaeffer 2013, Zipfel 2001), in that it intends to be taken as a pragmatically valid reference to a shared reality (notwithstanding that its declarations might be erroneous or mendacious, or the concept of reality metaphysically controversial). There can be little doubt that comics can be used in this way, and that such use is effective and compelling. The form of comics, it seems, does not predestine their content for either fiction or factuality.

McCloud uses the metaphor of a jug to convey this basic idea of a medium as a form opposed to its content (Fig. 1). Comics are a container; their content can be separated from its shape, and that shape might be studied on its own, an empty decanter. McCloud shows us this idea by drawing the container, but never mentions the word 'jug'; one might be tempted to think that the metaphor extends to the

imagery of these panels alone, while the text refers to the pertinent concepts directly and lucidly. Indeed, those concepts and McCloud's argument refer back to one of the most fundamental bases of media theory, McLuhan's famous admonition that "the medium is the message" (McLuhan 1964), while the content of any medium is another medium: in this case, the genres, styles, and trends that McCloud's visualization liquefies and promises to at least momentarily liquidate.



Fig. 1: McCloud, *Understanding Comics*, 1994, p. 6.

But those concepts are themselves metaphors, and McCloud is well aware that McLuhan's central argument will not yield to a straightforward isolation of the medium's message. The constant confusion of medium and content is not merely an irritation that the media analyst must avoid, but, at the same time, the core of media's very function that the analyst wants to examine. Media work precisely by bringing to our attention their content instead of their own shape. The style of the thoroughly cartoonish sequence in which McCloud's avatar drinks of that content takes us directly back to the vivid tropes so typical of comics' panels. One approach would be to consider the words of the avatar's speech to convey abstract meaning without such interruptions, if it were presented on its own in a text book. But no matter whether such a text book could ever avoid the messiness of its metaphors (it could not, for language is in its own way no less messy than cartoons): this text, in any case, is not presented that way, and the immediate resurfacing of the many colourful aspects of these drawings may engender doubt that those abstract thoughts can ever be quite purified of such distractions. As Frahm puts it, there is a parodist aesthetics to comics that ultimately parodies the idea of transparent signification itself (Frahm 2010). Understanding media, and thus understanding comics, cannot just be about separating the pure medium from its content; it must, at the same time, account for media's resistance against that separation.

The claim that comics can be factual is doubtlessly true. Its constant repetition, however, points to such resistance. Comics cannot merely be factual; rather, they can *surprise us by being factual*. Comics studies must not ignore that surprise, which plays a pertinent role in each of the factual comics mentioned. That surprise rests on the expectations created by an *interpretative drift*, a tendency to connect comics with one quality while knowing that said quality need not apply. Certain genres are expected in comics (superheroes, funny animals, adventure romps), even though we know that comics need not fall into those genres. The pure code of comics – perhaps "juxtaposed pictorial and other images in deliberate sequence", as McCloud puts it (1994, 9) – does not imply art, or even the depiction of visible scenes, much less the construction of a narrative. But more often than not, comics will present scenes and will use them to tell stories – and more often than not, those stories will be fictional and belong to certain genres. (For a more complete account of interpretative drift, see Packard 2016.) We readily accept comics that go against that trend; but the drift remains, pulling on our interpretation, resisting the factuality with an interpretative tendency of its own. The resultant tension, far from hindering the intended factual message, can be used to great effect in its service. McCloud does just that in the drawings of his instructive avatar and his conceptual metaphors, juxtaposing the metaphor for a pure code of comics with the sequence that immediately pulls it back into its familiar scenery.

My point here is not that there is anything within the formal makeup of comics that principally resists factuality. Rather, there is a current cultural disposition to read whatever formally resembles comics as likely narrative, likely fictional, and as less likely than serious. At the same time, there is in comics' aesthetics an invitation to a resistant graphic surplus created alongside any abstract idea conveyed. In current factual comics, that cultural disposition connects to this surplus, creating a specific parasitic space of tertiary significations that may both challenge and ultimately enrich the intended factual communication.

Parasitic Imaginaries

Fictional drift interlocks with the aesthetic devices that guarantee a surplus of meaning in the graphic presentation of comics that goes beyond the depicted. Perhaps the most fundamental device in comic books is the cartoon, as McCloud defines it (Fig. 2): The reduced and exaggerated depiction of the human body, focusing on those aspects that emphasize the action of any given scene, and that foreground communication among characters, but also between the depicted character and the reader (cf. Packard 2006, chapt. 4). Imbuing the depicted agents with the agency and potential for singular individuality that the reader herself possesses, the cartoon's semiosis combines the generalized iconic qualities of the simplified drawing with a suggested unique reference. Rather than seeing a universal depiction of any face, as we would at the extreme right of McCloud's scale, we need only go a few degrees to the left to imagine a vivid individual character about to take stage in the comic's narrative. In a similar way, the simplified outline

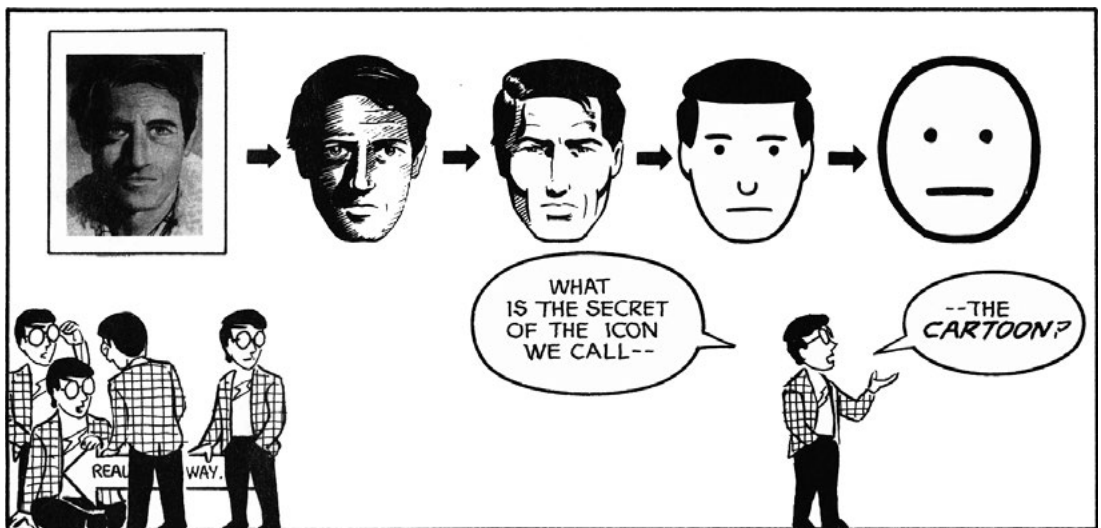


Fig. 2: McCloud, *Understanding Comics*, 1994, p. 29.

of Uncle Scrooge, even when further reduced to a mere silhouette as in this short sequence from one of Don Rosa's most famous stories (Fig. 3), by no means conveys a mere general shape of an anthropomorphic duck. Rather, it is precisely in this reduction that the image leaves us with no doubt: That is Scrooge!

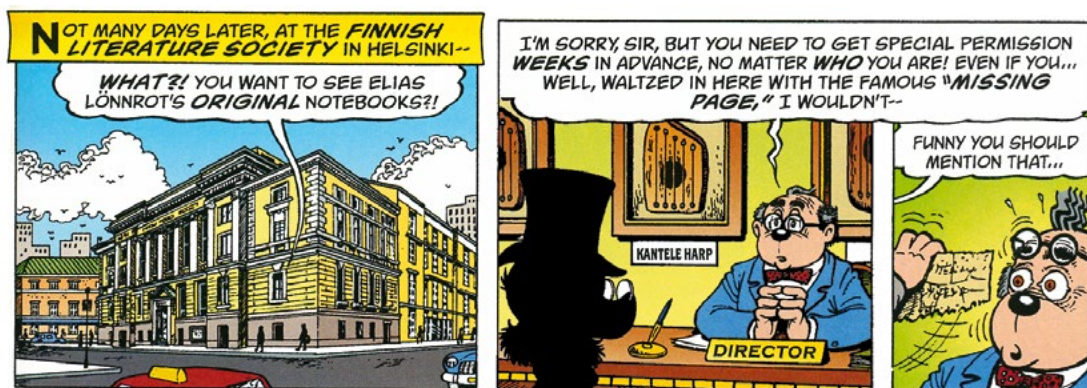


Fig. 3: Rosa, *The Quest for Kalevala*, 2004, p. 17.

But the previous panel contains a different kind of definite reference. The decisively uncartoonish style and accurate perspective that make the somewhat sober depiction of the building housing the Finnish Literature Society all imply to the routine reader of Rosa's comics that this is a factual reference. Indeed, society and building exist, can be found in Helsinki, and look very much like that building. The director, nameless or otherwise, will never have looked like the dog that Rosa presents next to Scrooge, however, and the 'Kantele Harp' in the painting next to him leads us to the neighbourhood of the imaginary Sampo, a wealth-promising magical artefact from the *Kalevala*, the elusive prize Scrooge wants to find. The short sequence embodies the masterful way in which Rosa juxtaposes factual and fictional references in his comic books, telling his readers about real Helsinki even while telling them a fantastic tale about that city. Again, there is nothing about the cartoon that necessitates fictionality in any general semiotic sense, but it belongs to the aesthetic resistance of the comic, and the fictional drift fastens on to that potential, pulling Scrooge and the unnamed director into the ongoing story and away from the more factually informative architecture to the left.

Mainly factual comics, of course, eschew anthropomorphic ducks and dogs and fairy-tale treasure hunts. But given the interpretative drift historically attached to comics, cartoon depictions cannot help but open third spaces with the potential for additional content. The cartoon iconically depicts a character that it resembles – but in a greatly reduced way; that reduction indexically connects it to the reader,

effecting a full character. Beyond the reduced primary similarity – Scrooge must look like the anthropomorphic hero he plays in the story –, additional shapes come up in the cartoon – Scrooge looks like a duck.

This need not be harmless. When Spiegelman's depiction of his father's survival of the Shoah (2011a) represents Jews as mice, the routine drift that would connect to the playfulness of Mickey Mouse is interrupted by national socialist propaganda that renders Jews as vermin; and more fundamentally, by any propaganda that identifies Jews by qualitative and recognizable essential traits. Spiegelman uses the ensuing confusion artfully: Because cartoons show us human bodies without showing us what they look like, readers, characters, and indeed the narrator all constantly experience uncertainty about the quality of identity – a 'living mask', as Frahm puts it, that beckons with the fantasy of suspicious recognition, which can be exchanged for others but never removed entirely (cf. Frahm 2006; Fig. 4). The art connects back to the racist underpinnings of caricature, which ever insists on recognizing essential qualities in physiognomic features; not least in the Vaudevillian blackface progenitors of Mickey Mouse's trickster appearance with his black-framed white-eyed face. If the fictional drift of comics suggests an interpretation as innocent genre literature, Spiegelman's approach reveals how such innocence is missing altogether from the origins of the cartoon. In this way, his comic is doubly factual: On the one hand, it deals with the real facts of the Shoah and his father's account. On the other, it deals equally seriously with the problematic reliance on visual recognition that drives comic books as well as the racist gaze that *MAUS* negotiates.



Fig. 4: Spiegelman, *Meta-MAUS*, 2011, p. 9.

MAUS is factual discourse. It achieves both its art and its factual reference to real issues not by avoiding or resisting, but by understanding and employing the devices of the comic book and its interpretative drift. Taking up the imagery of vermin once more, one way to understand these aesthetics might be in accordance with Serres' concept of the parasite, at once the interruption and the content of a given communication. In his central metaphor, the tax farmer interrupts the original production of paying subjects and takes his tax; but his enjoyment is again interrupted by the city rat feasting at his table after dark; who is interrupted according to the plot of the famous fable by the nervousness of the visiting country rat, who is ever ready to be interrupted as soon as it hears a noise that might suggest a predator, and so on (Serres 1980). By turning on its head the idea of mediation that casts the medium in the middle between addresser and addressee, or sign and signified, Serres captures the constant potential for confusion inextricably linked to the transparent function of media. The cartoon coming between the graphic depiction of a character and the represented person, the third space of the mouse nesting inside the cartoonish aesthetics, the racist underpinnings nested yet inside the imagery of the mouse, all demonstrate the inescapability of the parasitic imaginary that endlessly infests the comic's panels.

A Challenge for Factual Comics

A factual comic, then, is challenged to deal with the inexorably parasitic imagination elicited by the interpretative drift nesting in the cartoon. Once again, it would be a misunderstanding to think of their connection as immutable or essential: There is nothing about the cartoon that has to resist factuality, and nothing about factuality that abhors cartoonish pictures. On the contrary, factual comics are perhaps most successful when they are fully aware of and employ the divergences from linear signification offered by the tertiary contents of the cartoon.

Spiegelman's *MAUS* does this masterfully. In a different but nonetheless effective way, Joe Sacco's depiction of himself and others as cartoonish overstatements of their perceived physiognomy tackles the question of ethnic groups and racial stereotypes in the Israeli-Palestinian conflict on which he reports. Can a Palestinian or a Jew be recognized? By whom and by what? And whose side is Sacco on? Sacco's cartoons avoid answering these questions not by eluding them altogether, but by constantly drawing attention to their controversial categories.

Nick Sousanis presents a different kind of factual comic in his *Unflattening*. Rather than a biographic or documentary piece, his is mainly a philosophical reflection upon various schemata of thought and the possibility to open and transcend them.

While there are hardly any individual characters so firmly connected to his topic that they can be represented as if by necessity, and so the parasitic aesthetics of the cartoon cannot interrupt any otherwise seemingly realistic point of reference, the pages are nonetheless filled with scenes and characters, each taking different but effective advantage of the freedoms of the cartoon drawing. For instance, in the rigidity of collectivist and totalitarian dogmatic thought, each individual appears de-individualised by the kind of complete visual identity with every other person that can only be plausibly presented within the vagueness of cartoonish reductions. In another passage, the fungible appearance of a butterfly that is at once animal, interlocutor, and a dancer with a highly developed individual grace, exploits the potential of the cartoon. In each of these cases, the parasitic tertiary significations affordable to the cartoon and the seemingly anti-factual drift that connects to them are inverted and used productively to reference the real object of the discourse with even greater precision and a richer depiction.

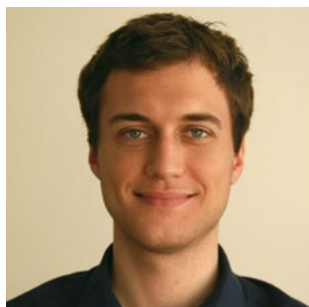
It seems to me that there is one opposite approach to this treatment of factuality in comics. McCloud's sequence with the jug at first implies that the written script that accompanies the images serves a transparent and lucid reference. The pictures would then become images transporting metaphors, or objects discussed in the discourse, and merely presented as static stills for the gaze of the speaker and their audience. McCloud immediately ruptures this impression with his cartoonish engagement as his avatar drinks the inkish 'content' of the medium's 'container'. The cartoon, in that sequence, is always already there, it precedes any purely lingual abstraction (which would itself merely offer the illusion of transparent signification anyway). It is when the text of a factual discourse precedes the image either logically or, in the case of several productions chronologically as well, that the pictures may be reduced to mere illustrations. Rather than being engaged in the dynamic of their sequence and alive with the readers' own singular individuation through the cartoon, they remain isolated, dependent upon individual written phrases whose meaning they repeat more than they rely on each other. They are the opposite of what Barthes called a 'relais': Neither do they have the relais' symmetrical relationship between picture and text, nor do they offer what he called 'anchors' in which elements from one code settle otherwise underdetermined elements from another (Barthes 1964).

If there is a normative suggestion that may follow from what was mainly intended as a descriptive account of factuality and one of its most striking devices in comics, it should perhaps be this: A comic artist is challenged to make conscious decisions about what to show. If we find that the text suffices, the comic is not needed. If the

cartoonish power of the comics' panels is either suspect or ignored, the subversive potential of the comic can turn against a factual intent through unmanaged fictional drift. Those factual comics excel that realize the non-realism, anti-representative nature of the cartoon as a freedom that can be exploited to full effect, and decide to make specific use of it as each case demands.

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Comics and Truth

Why Non-Fiction Comics need Rules

A comic can tell the story of almost anything: a single atom, the entire solar system, the past, future events, dreams and thoughts. All this, and more, can be depicted. When presenting facts, a certain artistic licence can be deployed if, for instance, the author wants to emphasise important details; likewise, aspects he or she deems irrelevant can be left out. Moreover, questions and issues can be laid out that are difficult or even impossible to portray photographically or cinematically (see Jüngst 2010, 182 or for example Ahmed 2015, Butler/Bresciani/Raymond 1968, Cannon/Cannon/Schultz 2010, Eisner 2008, Harder 2010, Leake 2015, and Warner 2015).

However, when the cartoon strip sets out its version of information, events, objects and people, it can also result in a distortion of reality. The graphic may not always make clear exactly how something looks or the precise way in which something happened. And even where documentary images exist, the comic strip representation of the non-fictional is always coloured by artistic interpretation (see Sacco 2012, XI f.).

Many journalists and artists who make use of comics as a medium are perfectly aware of this circumstance; many do not see any problem in the fact that comics journalism is a fundamentally subjective form of expression. As comic strip artist Josh Neufeld puts it in an interview, "[...] comics journalism has some leeway that other types of journalism may not. It's a mixture of journalism and art, and to me the 'art' part gives license to reconstruct some scenes – if it serves the truth of the larger story." (Neufeld 2012). In the preface to *Creating Comics as Journalism, Memoir, and Nonfiction*, Neufeld goes further: "[...] I reserve the right to compress scenes, eliminate minor characters, and even (in rare cases) invent dialogue – as long as these techniques serve to convey the *emotional* truth of the story." (Neufeld 2016, xi.). In the preface to his book *Journalism*, comic strip artist Joe Sacco writes, "The cartoonist draws with the essential truth in mind, not the literal truth, and that allows for a wide variety of interpretations to accommodate a wide variety of drawing styles." (Sacco 2012, XII.). From this standpoint, it is not a matter of accurately reproducing everything in photographic detail; what counts is rather the overall truth of the account of what has happened. Sacco's consciously subjective journalistic

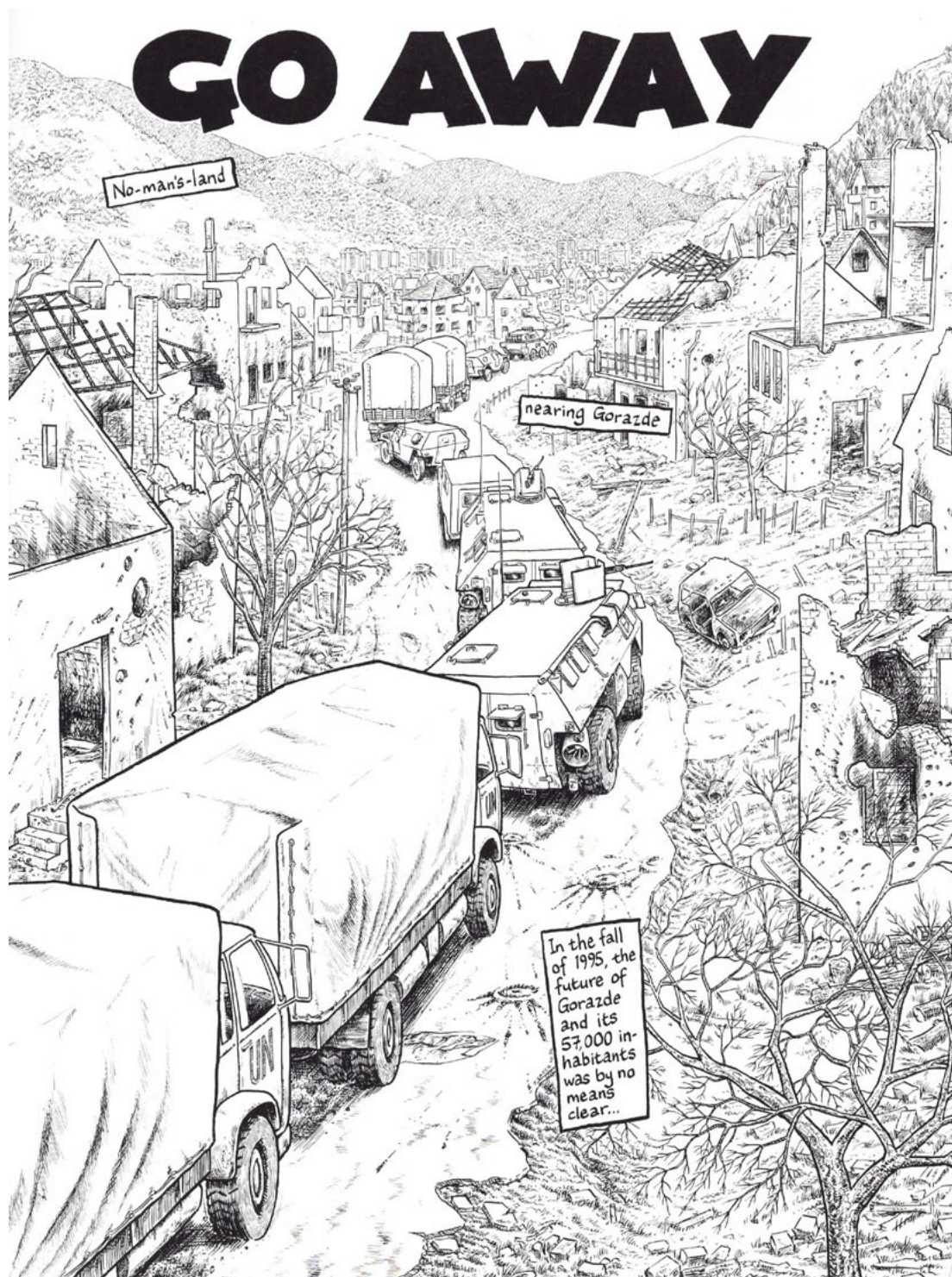


Fig. 1: Sacco 2011, 1.

comic strips may be understood as a criticism of the journalistic quality criterion of 'objectivity' (see Dong 2015, Gardner 2015, Macdonald 2015, Singer 2015).

All these considerations do not, however, mean that no limits to artistic freedom are recognized where facts are involved. Like many comic artists who depict real events in their work, Sacco is convinced that representation should be as close to the truth as possible, noting "[...] anything that *can* be drawn accurately *should* be drawn accurately [...]" (Sacco 2011, 1; Fig. 1; see also Duncan/Stoddard/Taylor 2016, 102ff).

A brief survey of existing non-fictional comics shows that their authors, whether artists, scientists or others, have very different ideas of how much artistic licence is appropriate when presenting facts (see for example Benson 2011, Cannon/Cannon/Zander 2010, Cunningham 2012, Delisle 2012, Fagerstrom/Smith 2011, Feindt/Schraven 2015, Hamann/Leinfelder/Zea-Schmidt 2012, Harder 2010, Igort 2012, Jysch 2012, Sousanis 2015, Ulrich 2005 and Plank 2013, 93ff.). A non-fictional comic may be exclusively based on the experiences of the artist, or contain information that has been garnered from a variety of sources. Several comic narratives recount only real events but contain imaginary figures or quotes.

For the media consumer, this means a multifaceted and confusing range of non-fictional comics. This poses a problem where terms such as 'comics journalism' are used. Benjamin Woo writes on this issue: "Given the dominance of the discourses of objectivity and verification in the journalistic field, I maintain that the label 'comics journalism' is misleading." (Woo 2010, 176; cf. Singer 2015, 69ff.) The issue is one that is not limited to graphic art. The term 'journalism' itself is exceptionally diverse: It can be interpreted in different ways and understood from the viewpoint of a particular quality standard (see Fabris 2001, 43ff.; Funiok 2006, 192; Ruß-Mohl 1992, 85; Karmasin 1998, 322ff.). Rules and standards have become established where journalism, in general, is concerned, and these are applied in the quality media (see Karmasin 2010, 226ff. and Duncan/Stoddard/Taylor 2016, 240.). They enable individual works to be compared and verified – albeit with limitations. For comics journalism or comics that present facts, there are no such uniform rules and criteria. A recent exception to this is *Creating Comics as Journalism, Memoir and Nonfiction* (see Duncan/Stoddard/Taylor 2016). This is not to say that comics in themselves are less suited to representing facts than other journalistic forms. As noted above, many comic artists are extremely conscious of the extent to which one is permitted to interpret or manipulate when representing the real. It would seem a useful question to ask what *consistent* rules and standards should apply specifically to non-fictional

comics. Existing journalism ethics can, of course, be applied to comics journalism, but this raises the question of how to interpret individual guidelines and whether these could even be adhered to in practice. The *Code of Ethics of the Society of Professional Journalists* instructs journalists to "[n]ever deliberately distort facts or context, including visual information. Clearly label illustrations and reenactments." (SPJ's National Convention in Nashville, Tennessee 2014.) The *Code of Ethics* of the National Press Association points to the following requirements: "Editing should maintain the integrity of the photographic images' content and context. Do not manipulate images or add or alter sound in any way that can mislead viewers or misrepresent subjects." (National Press Photographers Association 2012). And the Press Code of the German Press Council says, "Where an illustration, in particular a photograph, may be perceived from a cursory reading as a documentary image, where it is in fact an example, appropriate clarification is required." (Deutscher Presserat 2015). In the following, I attempt an overview of current rules, standards, and strategies for assuring journalistic quality in non-fictional comics.

So that readers may assess where a specific comic lies on the spectrum between the poles of fact and fiction, it seems sensible to inform them how the story arose and what information sources were used. It would also seem important to ensure transparency with respect to any manipulation of graphic and non-graphic elements to give readers clarity.

One way of ensuring transparency would be to provide prefaces. Turning to journalism once again, we can note that Sacco's written preface to the collection of comic strip stories gives the reader a feeling of the author's method of working, his view of objectivity, and the rules to which he, as a comic strip journalist, adheres (see Sacco 2012, pp. XIff.). The comic book artist Jessica Abel also furnishes her *Out on the Wire. The Storytelling Secrets of the New Masters of Radio* with a preface – albeit a graphic one. In it, she explains how the comic came about. She also lays down her treatment of quotations (see Abel 2015, 6.; Fig. 2).

Transparency can naturally be achieved beyond the confines of a preface or afterword. For example, source material can be made available even if it is not comprehensive. Printed transcripts in the form of an appendix or links to material, photographs, and audio or video clips also help the reader to gain an impression of how much the images and words have been manipulated. Footnotes can be used to direct the reader to a source used for a cartoon panel. It is also possible to place particularly important sources – such as photographs or documents – directly in the comic strip or to make them available via links. In his comic strip *What is*



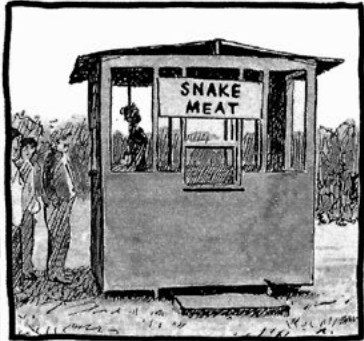
Fig. 2: Abel 2015, 6.

EDITOR'S NOTE: Some dialogue below and on the following pages is comedic fiction inspired by reporting.

HERE WE ARE, TWO MINUTES INTO THE BIGGEST RACE OF OUR LIVES, AND MY SNAKE HATES ME. HE'S GLARING AT ME LIKE I JUST KILLED HIS WIFE WITH A HOE. IT'S THE SAME LOOK A TEXAN GETS WHEN VISITING ASPEN. IT'S DISCONCERTING, BUT WHAT RATTLES ME MOST IS THE ACTUAL RATTLING. IF YOU'VE NEVER HEARD IT IN REAL LIFE, IT'S DIFFERENT THAN IT IS IN THE MOVIES. IT'S FASTER AND SOUNDS LESS LIKE A DISTINCT RATTLE AND MORE LIKE A SINISTER HISS. IMAGINE SATAN MAKING BACON.



SPEAKING OF THINGS FRYING, I JUST NOTICED ANOTHER REASON WHY MY SNAKE MIGHT BE ACTING THIS WAY. WE'RE DIRECTLY DOWNWIND FROM THIS ...

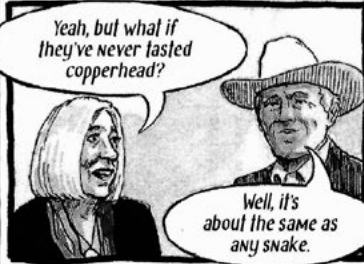


THEY'RE FRYING UP CHUNKS OF RATTLER AND SELLING THEM FOR FIVE BUCKS A POP. FURTHER PROOF, IF IT WAS NEEDED, THAT TEXANS WILL DEEP-FRY JUST ABOUT ANYTHING.

THE 5 THINGS YOU NEED TO ENJOY FRIED RATTLESNAKE

1 SKINNED SNAKE	2 PRUNING SHEARS	3 CORN MEAL	4 DEEP FRYER	5 TRASH CAN

YEAH, I'M NOT A BIG FAN. I'VE TRIED IT A BUNCH OF TIMES. THIS MIGHT SURPRISE SOME OF YOU NON-TEXANS OUT THERE, BUT THE FIRST TIME I TRIED FRIED RATTLESNAKE WAS AT CHURCH. YOU SEE, TEXAS CHURCHES, UNLESS THEY'RE UNITARIAN OR SOMETHING, ARE ALMOST SURE TO BE CHOCK-FULL OF SPORTSMEN, SO CHANCES ARE GOOD THAT SOME KIND OF WILD GAME, WHETHER IT'S VENISON, SQUIRREL, OPOSSUM, OR RATTLESNAKE, IS GONNA SHOW UP AT THE POTLUCK DINNER. A LOT OF FOLKS WILL TELL YOU THAT RATTLESNAKE TASTES LIKE CHICKEN, BUT THAT'S NOT QUITE RIGHT.



Comics Journalism?, Dan Archer provides links in panels and in other places to online articles – one click suffices and the website with the relevant source material opens. (Archer 2011). Other examples show that background or source material can be integrated into web comics in the form of audio files and video clips (see for example Cagle 2012, Gennis 2014, Ndula 2014, Ndula 2013, Ortiz/Paim/Piccini 2013 and Radl 2012).

Prefaces and afterwords, attachments, footnotes, links, photographs, videos, sound recordings and so on can show where information comes from and give readers an idea of whether that information has been altered in the presentation. This applies not only to graphic but also to non-graphic aspects, for instance, the text in speech bubbles, where there is limited space for quotes.

Josh Kramer publishes the comics journalism magazine *The Cartoon Picayune*. Generally, only direct quotes are given in its speech bubbles (see Plank 2013, XXXVIII.). Where one comic departs from this rule, Kramer has opted to add a note: "Some dialogue below and on the following pages is comedic fiction inspired by reporting." (Kramer 2012, n. p.; Fig. 3).

Comics can also feature non-fictional content that takes place in a fictional field of action (see for example Benson 2011, Cannon/Cannon/Schultz 2010, Donna et al. 2011, and Krause et al. 2016). However, where a comic appears to be concerned with real life, it would seem reasonable to require that basic journalistic standards be applied (see for example Deutscher Presserat 2015, SPJ's National Convention in Nashville, Tennessee 2014 and National Press Photographers Association 2012). It should not be permissible for quotations to be made up, relayed in the wrong context, or abbreviated to the extent that core statements are lost. It seems similarly inappropriate to invent people, objects and events, or to manipulate their placement in time and space. Deviations from these regulations need not be ruled out completely, but it should be clear where they occur. Substantial changes should be signalled as such – something that has been invented may not be sold as true.

Once the chosen journalistic approach, conditions of production, and degree of manipulation or abstraction are made transparent and the depicted subject matter is placed in its context, readers will be better equipped to attach a classification to the non-fictional comic (see Plank 2013, 101ff.). One could also imagine every panel being labelled with a symbol: this would allow the source of information presented to be made clear at a glance (see Plank 2013, 111ff.). It would also seem to be a good idea to give readers the opportunity to provide feedback and criticism (see Plank 2013, 124ff.).

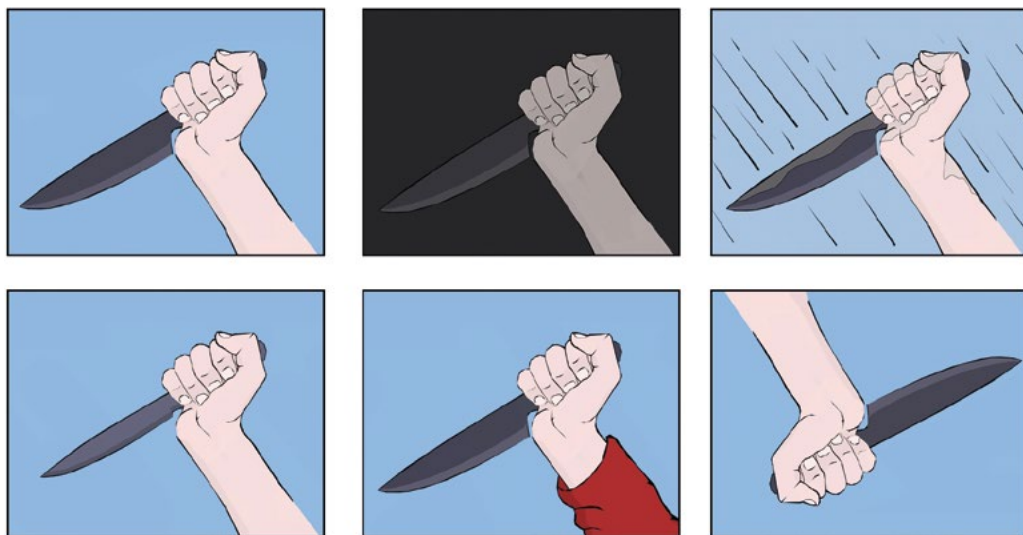


Fig. 4: Own figure based on Plank 2014, 9.

The authors and artists engaged in producing a non-fictional comic should ask numerous 'visual questions'. "When relying on eyewitness testimony, I ask pertinent visual questions: How many people were there? Where was the barbed wire? Were the people sitting or standing?" (Sacco 2012, XII.).

Writing a short newspaper article about an event requires only a little core information. In most cases, the portrayal of the same event in a comic, on the other hand, requires far more information. If someone is attacked on an open street with a knife, a few supplementary details are enough to portray the event in an article. But to do justice to the truth in a comic, numerous visual aspects are relevant: What kind of surroundings did the event take place in? How late in the day was it? How was the weather? What was the knife like? Was the attacker male or female? What type of clothing was he or she wearing? How exactly did the attack come about? Only when these and other questions have been answered should the event be represented in an exhaustive drawing (Plank 2014, 9; Fig. 4).

Other graphic non-fictional forms of representation are often dependent on 'visual information', too. In journalistic texts where there is a lack of visual information, the writer's interpretation and manipulation of issues will to some extent be transferred to the reader. Whenever an event is described in a newspaper article, its readers may form dramatically different impressions. The problem of manipulation is thus not restricted to comics. For example, interview scripts are normally reworked; photographs may seem to reproduce reality in an unfiltered manner, but may, in

fact, have undergone various types of editing. The very selection of an image is a type of manipulation (see Haller 2008, 342f.; Littek 2011, 64; Miener 2004, 54f. and Freund 1997, 7).

This puts the call for a discussion about quality criteria for non-fictional comics in a broader context. However, it does not make it less relevant. In comics, almost everything can be made concrete, as image and words – and often with comparatively little expense or effort. The particular strength of the medium should be accompanied by a heightened sensibility for the associated opportunities to manipulate the truth.

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Jaqueline Berndt

Manga meets Science: Going beyond the Education-Entertainment Divide

How readers perceive science comics is swayed by the general notion of comics they hold, in particular with regards to the question "... why call such works comics at all?" (Duffy 2015: 5). For most regular readers, comics are anything but a context-transcending medium of representation that interrelates image and text, simultaneity and sequentiality, page and panel. "Comics can name a means of communication and/or an aesthetic visual style and/or particular narrative tropes and/or a subculture and/or an industry." (ibid.). Conventions, connotations, and cross-references shared by specific readerships are not to be dismissed when weighing the odds of a comics' educational impact.¹ It is the 'culturally qualifying aspects' rather than the technological, material, and semiotic properties that warrant 'comicalness' (Wilde 2015). In other words, the perception of comics is shaped as much by textual features and paratextual elements which may invite, for example, educational readings, as by readers' experience within a specific mediascape which may defer narrow educational intentions.

In Japan, most contemporary readers expect comics, or manga², to be entertaining fiction (*story manga*), magazine-based, and targeted at age- and gender-specific demographics. These narratives eventually reappear in bound book editions (*tankōbon*), after they have proven to be popular to an extent that would warrant print runs of more than 5,000 copies. Due to the central role of magazines as first site of publication since the 1960s, genre specificity has been essential – for editors, readers, and artists alike. While manga's traditional genres have been gender- and age-specific, thematic genres such as SF, horror and comedy, or recently also blog-like *essay manga*, come to the fore whenever the otherwise prevalent categories forfeit efficacy. But there is one genre which does not comply with these categories, i.e. *gakushū manga*, educational or instructional comics (lit. *manga to learn something from*). Difficult to determine with regard to both its formal particularities and market share, and more or less unheeded by manga critics, this genre provides one site for science to meet comics. As issues of global concern such as the Anthropocene Kitchen did not surface in Japanese news media let alone manga, this article

¹ In line with recent English-language comics studies, this article deliberately uses *comics* for both the singular and plural.

² In line with Japanese and Japanological custom, this article uses Japanese nouns in the plural without 's'

focuses on science comics in a more general sense with an emphasis on comics rather than science, trusting in the agency of the comics media³, i.e. that comics is more than a mere 'container' of assumingly stable knowledge.

1. *Gakushū Manga*, an Inconspicuous Genre

Science comics (*kagaku manga*) began to aid school education with a more or less patronizing attitude in the late 1930s (Itō 2013: 206), and they gained momentum from the mid-1950s onwards, concurrently with the Japanese equivalent to *Classics Illustrated*, i.e. editions of *Famous Literary Works as Manga*. In contradistinction to purely entertaining material, both types have traditionally been positioned as educational comics (*gakushū manga*). Within the educational domain, literature, history, and practical skills have featured more prominently than science, especially since the 1980s when adult readers started to reach out for initially child-oriented publications such as *Hello, Personal Computer!* (*Konnichi wa maikon*, 1982) by Sugaya Mitsuru⁴ (b. 1950). In an investigation conducted in 2008, Sugaya listed also law, nursing care, statistics, and so-called qualifying examinations among the thematic genres of educational comics popular with adult readers. Promoting manga to these readers as a tool of efficient learning – an entry point to acquiring basic knowledge as prerequisite for handling more specialized publications – Motoyama Katsuhiro (2012) foregrounds accounting, business administration, and national economy. Subjects like these were pioneered by renowned manga artist Ishinomori Shōtarō (1938-98) and his production studio.⁵ Their *Japan, Inc.: Introduction to Japanese Economics* (*Nihon keizai nyūmon*, 1986-88) (Fig. 1) became a bestseller with salarymen in Japan and one of the very first manga to be translated into Western languages.⁶ While presenting facts in form of an engaging narrative, its publication did not take the form of manga-magazine serialization, and precisely this positioned it as a *gakushū manga* within the Japanese mediascape.

Readers beyond the age of elementary school children encounter *gakushū manga* usually in book form, although not necessarily that of the manga *tankōbon* released by a publisher specialized in manga.⁷ Mostly drawn by artists without reknown in the field of manga entertainment⁸, *gakushū manga* books have traditionally been hiding behind non-spectacular cover designs, which at times even indicate the name and affiliation of an academic supervisor. This packaging has facilitated

3 For the notion of *media* (as a collective singular), as distinct from *medium* or *mediums*, encompassing not only technical, or technological, but also aesthetic and societal aspects, see Mitchell/Hansen (2010).

4 Japanese names are given in the domestic order, surname preceding first name without separation by comma except in the Works Cited list. Sugaya's volume received one of publisher Kodansha's Children Manga Awards in 1983, together with a second one titled *Game Center Arashi*.

5 Volume 1 was not yet drawn by Ishinomori himself but his staff.

6 Eng. trans. 1988, Ger. trans. 1989.

7 Another popular format are series of booklets (consisting of 34 pages and sized bigger than A4).

8 See for example the adaptations of literary works within the *Manga de Dokuha* (lit. *reading through with manga*) imprint created by an anonymous collective and published by East Press (since 2007).

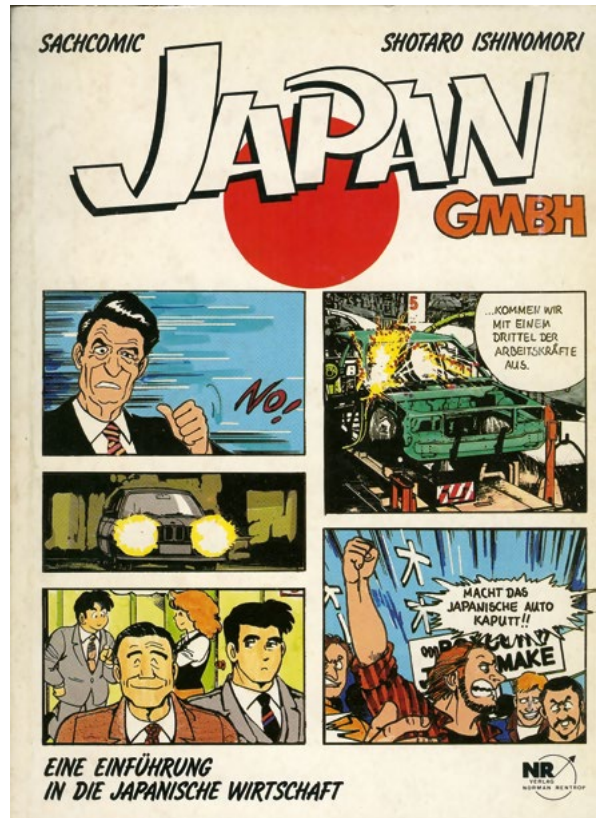


Fig. 1: Ishinomori Shōtarō (1989):
*Japan GmbH: Eine Einführung in die
 japanische Wirtschaft.*
 Bonn: Rentrop. Cover illustration.

parents' acceptance (and expenditure), but also a certain wariness on part of regular consumers with regards to treating such comics as manga proper. The "distant relationship between educational comics and the cultural institution of comics" (Duffy 2015: 4) is nothing particular to a specific country, although the extent to which educational comics are "produced outside the editorial regimes, print production and distribution methods, fan and artist communities, and entertainment industry tie-ins so often associated with comics as popular cultural production" (ibid.) differs, due to the size of the domestic Japanese manga market and its genre-specific bifurcations as well as the increasing degree of blending fact and fiction, educational earnestness and mangaesque fun.

As is well known, manga is divided into gendered genres, but without the tie to a specific magazine, educational manga exhibit less gendering, which means in turn that they resort, by tendency, to male genres (i.e. manga for boys and men) as the most widely sharable styles while eschewing fan-cultural fashion to not detract from the primary, educational purpose.⁹ Although not a comics, the revised edition of the English textbook for junior high school students *New Horizon* by publisher Tokyo

⁹ This is the reason why they have been "largely found in shōnen and sēnen [sic!] manga", as Murakami/Bryce observe (2009: 50).

Shoseki is a telling example in that regard. Within a few days after the beginning of the school year in April 2016, a newly introduced character – the cute blond teacher Ellen Baker (Fig. 2) – went viral on fan sites and social networking services. Denchūbō, the male artist who created her, "said he was incredibly happy to see Baker getting so much attention, [but] if the character starts getting too much



Fig. 2: Denchūbō: Ellen Baker character, April 2016

notoriety for things other than her academic contributions, parents and guardians might not take kindly to it" (Baseel 2016: n.p.). In other words, the kind of mangaesque character design which incites fannish appropriation may appeal to students and publishing houses, but not necessarily educators. This falls into line with Duffy's observation that "the educational institutional context uses comics and animation to draw attention, but also to temper narrative engagement by redirecting reader focus on didactic learning" (2015: 9) – although the engagement triggered by the Ellen Baker character is not exactly a narrative, but a post-narrative one, driven by a strong affection towards cute characters and their appropriation in fan fiction and fan art rather

than a primary interest in narrative and author.¹⁰ Against the backdrop of recent database-oriented approaches to popular media texts and fans' game-like imagination¹¹, Itō Yū, researcher at the Kyoto International Manga Museum, calls for analyzing *gakushū manga* not only from the perspective of the imparted knowledge, but also character design, as familiar mangaesque character types invest, for example, the representation of historic personae with a specific contemporary media-induced actuality (2013: 217-218). For publications to get accepted by educators, however, it is vital to cater to pedagogic rather than comics-specific concerns, including fan-cultural ones.

While character design operates as a powerful visual attractor of attention, educators are inclined to focus on the verbal component of comics as the primary conveyer of knowledge. But the dialogue, too, may take a mangaesque, i.e. an affect rather than cognition-oriented, form. In this regard, the case of the high school mathematics textbook published by Keirinkan in their *Olé!* series in early

¹⁰ Cf. Itō Gō 2005, Galbraith 2009.

¹¹ Cf. Azuma 2009, Kacsuk 2016.

2007 is worth mentioning. When submitted to the MEXT¹² Textbook Screening Committee it got approved only after revisions: The amount of pages that presented mathematical issues in the form of colloquial dialogues between mangaesque characters – initially 70 out of 183 – had to be reduced to 20, and the casual short form, common among teenagers, was to be changed to standard Japanese. While the Committee objected to the lack of a necessary link between mangaesque parts and learning content – in particular with the argument that "it is hard to understand the [pedagogic] intention behind certain remarks by the teacher character" (Nagai 2007: n.p.) – it overlooked the primal issue: the growing need to pique students' interest in science. Any attempt to stimulate that interest by affective means – whether verbal or visual – meets with resistance on the part of educators to whom those means appear merely 'decorative'.

In contradistinction to textbooks, educational comics do not have to pass the ministry's screening. Consequently, they have been free to unfold manga-typical properties, namely humorous exaggeration, appealing narratives, and anthropomorphization, or – more advanced and media-specific – 'characterization'.¹³ This inclination surfaced already in the 1950s, for example, in *Manga Biology* (*Manga seibutsugaku*) by Tezuka Osamu (Fig. 3, 4, see next page). Five years after the launch of *Astro Boy* (*Tetsuwan Atomu*, 1952-1968), Tezuka, the trailblazer of Japanese graphic narratives, serialized his later award-winning science comics on biology in an educational journal for junior high school students (May 1956 - March 1957). It is

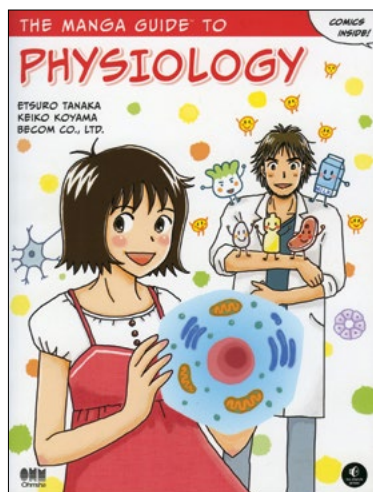


Fig. 5: Etsuro Tanaka/ Keiko Koyama/ Becom Co., Ltd. (2016): *The Guide to Physiology*. San Francisco: No Starch Press/ Ohmsha. Cover.

composed of lectures by the recurrent character Dr. Anything and Everything (*Nandemokandemo hakase*) and independent episodes, which sometimes feature anthropomorphized animals, sometimes a Science Fiction setting. Noteworthy enough, Tezuka himself was aware of the necessity to aim for an equilibrium: "If we exaggerate too much, it becomes a mere manga, losing its characteristic as science comics, and if we represent things in a real way, then it gets bookish and loses its mangaesque character." (op. cit. Itō 2013: 212).

Sixty years later, Japan's science comics have become vast in number, but they rarely exceed the domestic market, one of the few examples being the *Manga Guide* (*Manga de wakarū*) series by publisher Ohmsha, which was launched in 2004 and has since seen translated editions released in collaboration with American and Brazilian publishers, among others (Fig. 5). The

¹² Japan's Ministry of Education, Culture, Sports, Science and Technology.

¹³ Cf. Nozawa 2013.



Fig. 3: Tezuka Osamu (2009 [1957]): *Manga Seibutsugaku* (Tezuka Osamu Manga Zenshū, vol. 279). Tokyo: Kodansha. Cover.

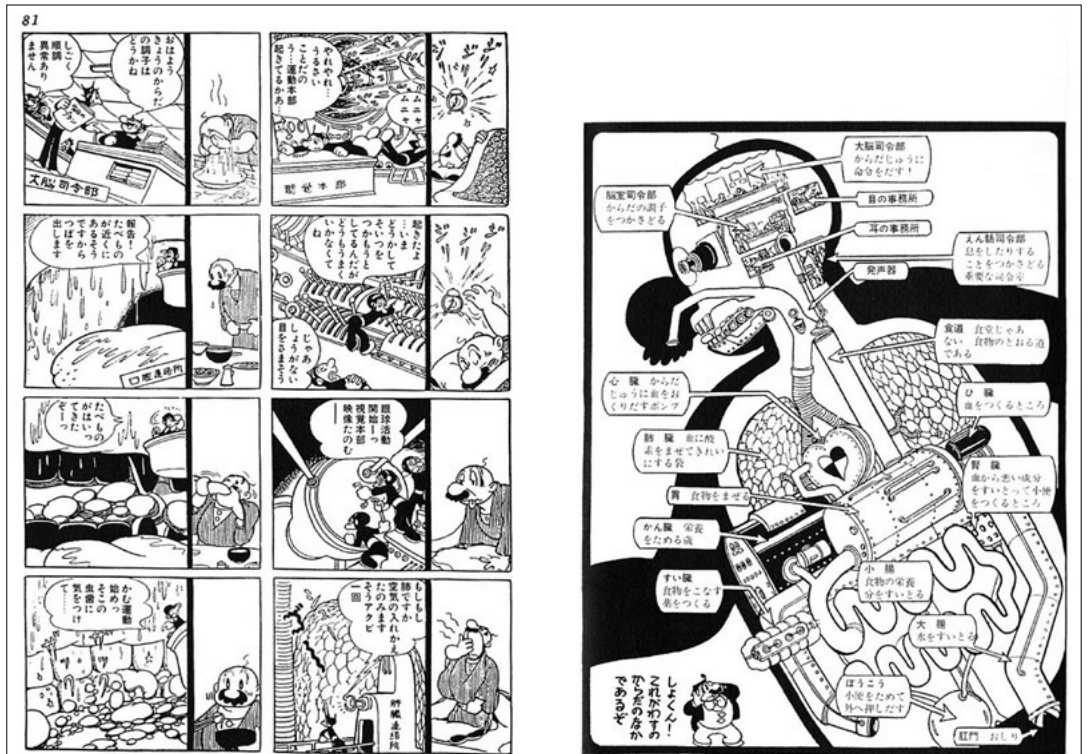


Fig. 4: Tezuka Osamu (2009 [1957]): *Manga Seibutsugaku* (Tezuka Osamu Manga Zenshū, vol. 279). Tokyo: Kodansha. pp. 80-81 [reading direction from right to left].

biggest player with regards to educational comics in Asia is South Korea. Appearing in books with sturdy bindings and good-quality paper, educational manhwa hold a 50% share of the domestic comics market (Lim 2011: 44), and they have been gaining ground in the People's Republic of China, Taiwan, Thailand, Indonesia, and Malaysia as well. Characterized by a ratio of 65% education and 35% entertainment, as critics have ascertained, their most representative series are the science comics *Why?* by publisher Yea Rim-Dang (since 1989/2001¹⁴, 50 vols. in total; Fig. 6) and the 18-volume aid to learning Chinese ideograms *Magical Thousand Characters* (*Mabeop Cheonjamun*) by publisher Owl Book, started in 2003. Leaning on the Chinese novel *Journey to the West* as well as Toriyama Akira's manga *Dragon Ball*, the latter employs Sun Wukong (Son Gokū), the monkey king, as its protagonist who now has the gift of spelling magic words (Fig. 7, see next page). While this series is also available in English (addressed to Korean learners of the language, Fig. 8, see next page), a Japanese version has not been released as distinct from the *Survival* series by Korean publisher Mirae N Culture¹⁵. One volume of this series, scripted by Hong Jae-Cheol and illustrated by Mun Jeong-hoo (2004), addresses *Earthquake Survival* (*Jishin no survival*). The preface points to the Kobe earthquake of 1995 and states that Korea is not necessarily safe of such danger. The all-color manhwa itself relates the story of a Korean father and his two kids who go to Japan for a hot-spring trip but get eventually caught in an earthquake and tsunami (Fig. 9).

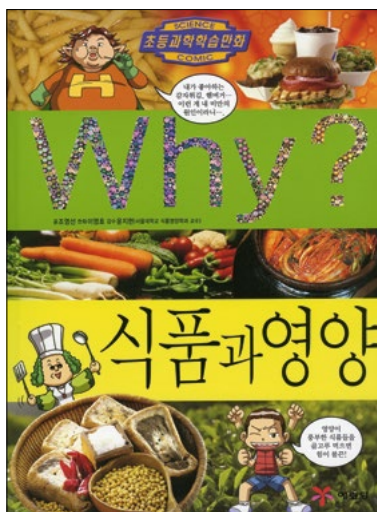


Fig. 6: Na Seunghoon (2008): *Sikpoom gwa yeongyang* (*Why? Food and Nutrition*). Seoul: Yea Rim-Dang. Cover.



Fig. 9: Hong Jae-Cheol (script) & Mun Jeong-hoo (art): *Jishin no survival*, Kagaku manga series (*Earthquake Survival*). Tokyo: Asahi Shinbunsha 2008. Cover.

¹⁴ With an eye to foreign markets, the series name was changed to the English *Why?* in 2001.

¹⁵ Japanese edition under the name of *Science Comics* (*kagaku manga*) by the publisher of one of Japan's biggest newspaper, Asahi Shinbunsha.

2. Beyond the Education-Entertainment Divide

"Prioritizing communication over aesthetics and information delivery over narrative engagement" (Duffy 2015: 4) and the implied downplaying of aesthetic and affective aspects in favor of a performed neutrality are reminiscent of the documentary mode of address as discussed by Nina Mickwitz (2016: 24), but they are not necessarily characteristic of educational comics in South Korea and Japan, and neither is the assumed distance from commercialism. In other words, the Western notion of *non-fiction comics* (Ger. Sachcomics) which rests on the assumed opposition between fact and fiction, education and entertainment, culture and commerce, does not necessarily apply, and this is due not only to cultural differences but also the age of digitalization in which such segregations are becoming obsolete all over the world.

By now, educational manga appear in a vast variety of forms, stretching from entirely fictionalized accounts to talking-heads, occasionally including hybrids of purely textual passages and a few paneled pages in-between. Sugaya (2008) differentiates five types, the least comics-like ones being text-centered explanations accompanied by one-page illustrations with mangaesque characters (Fig. 10) and the *For Beginners* series, which, due to its graphic-design appearance, i.e. the small amount of paneled pages, makes it reportedly hard to read for Japanese consumers¹⁶. A third type identified by Sugaya are educational books with an introductory part rendered in

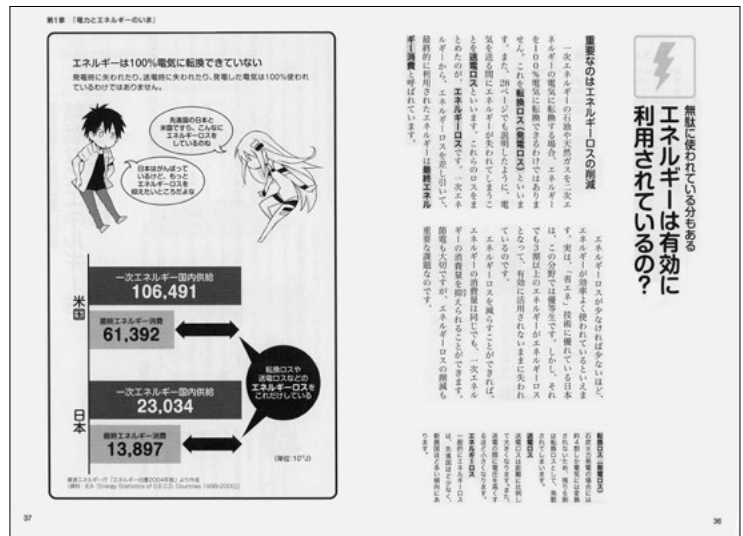


Fig. 10: Futahiro Tokihiko/Sideranch Co. (2011): *Manga de wakaru: Enerugi no shikumi* (Understanding through manga: The way energy works), supervisor Iida Tetsuya. Tokyo: Ikeda Shoten, pp. 36-37

¹⁶ Started in Mexico in 1966, the first translated Japanese edition (*Freud*) was published in 1980 by publisher Gendai Shokan, the first original Japanese volume in 1982. In the 2000s, an originally Japanese *For Beginners Science* series was also released (13 vols in total), dedicated mainly to ecological and health issues including cosmetics and food safety.

the form of a graphic narrative. *Manga de waku: Enerugi no shikumi* (*Understanding through manga: The way energy works*) by Futahiro/Sideranch Co. (2011), for example, opens with six paneled – and colored – pages: College student Yōta has an assignment to write an essay about Japan's energy issue, but is not interested at all until the female alien Hikari arrives who needs a significant amount of electric power to return to the future where she comes from. This sequence is followed by short sections each beginning with a title in the form of an interrogative clause and providing answers by means of written text and illustrations in a restrained mode. But 52 out of the 248 pages present a graphic narrative and extend it to the point where solar energy is finally used to help the cute alien, clearly referencing the media experience of young readers but as distinct from educational manhwa still clinging to monochrome printed comics rather than glossy all-color surfaces reminiscent of anime, video games, or webtoons (Fig. 11).



Fig. 11: Futahiro, Tokihiko/ Sideranch Co. (2011): *Manga de waku: Enerugi no shikumi* (*Understanding through manga: The way energy works*), supervisor Iida Tetsuya. Tokyo: Ikeda Shoten, pp. 244-245 [reading direction from right to left].

The two prevalent types of educational manga, however, employ paneled pages throughout. While the more classic variant conveys the learning content via a more or less funny teacher-pupil relationship drawn in a rather cartoony style, the bulk of educational manga today are actually graphic narratives, entertaining fiction which allows to focus on both the knowledge and the human interest story (or either one). The prevalence of the latter started in the mid-1980s when artists and editors began to include specialized expertise in the hope that it would work like a souvenir, i.e. stick in readers' memory together with the artist's name. By now, this strategy has become mainstream, suffice to mention the ninja-related information in Kishimoto Masashi's *NARUTO* (1999-2014), the reference to the traditional board game in *Hikaru no Gō* by Obata Takeshi/Hotta Yumi (1998-2003), or the central role of traditional Japanese playing cards in female artist Suetsugu Yuki's *Chihayafuru* (since 2007). But there is also an explicit focus on science in some recent graphic narratives serialized in representative manga magazines. Hebi-zou¹⁷, a female artist who had first gained renown with the series *Nihonjin no shiranai nihongo* (*The Japanese the Japanese Don't Know*)¹⁸, has been successfully running the series *Kesshite mane shinaide kudasai* (*Please, do not attempt, never*, Fig. 12) in the manga monthly *Morning* since 2014. In ironic contrast to the series title's warning, every chapter features a risky experiment conducted by a group of physics students under the supervision of their handsome professor, who brings into play the basic scientific knowledge as well as the historic scientists who discovered it. One day the students explore, for example, why stuntmen do not get burned when their bodies are covered with flames (Fig. 13).



Fig. 12: Hebi-zou (2014): *Kesshite mane shinaide kudasai* (*Please, do not attempt, never*), vol. 1. Tokyo: Kodansha. Cover.

¹⁷ Her penname translates literally as 'storehouse of snakes'.

¹⁸ Scripted by Umino Nagiko. Gentōsha 2009-2013, 4 vols.



Fig. 13: Hebi-zou (2014): *Kesshite mane shinaide kudasai* (Please, do not attempt, never), vol. 1. Tokyo: Kodansha, pp. 14-15 [reading direction from right to left].

Another manga by a female artist, Shimizu Akane's debut work *Hataraku saibō* (*Cells at Work*), which has been appearing in the boys manga weekly *Shūkan Shōnen Sirius* since 2015 and filled three tankōbon volumes so far, presents stories from the inside of the human body, namely about the cells which warrant its immunity. These cells appear as anthropomorphic characters. In the very beginning, the female lead – the red blood cell AE3803 – tries to ward off an attack by the monster-like *Streptococcus pneumoniae*, but to win she needs support by the handsome guy called White Blood Cell (Fig. 14, 15). The fact that the medical terms as such serve as character names – the reader meets, among others, Macrophage, Myelocyte, and T-lymphocyte – is highly unusual but extremely effective and justifies the genre categorization of this series as science manga.

What Shimizu carries to extremes, i.e. the entwining of character-driven entertainment and education, is acknowledged not only by manga readers but also the Nippon Foundation's Manga Edutainment project (*Kore mo gakushū manga da!*),



Fig. 14, 15: Shimizu Akane (2015): *Hataraku saibō*, vol. 1. Tokyo: Kodansha (Sirius KC), Fig. 14: Cover, Fig. 15: pp. 8-9 [reading direction from right to left].

launched in 2015.¹⁹ Under the auspices of veteran artist Satonaka Machiko, one hundred titles have been selected. Remarkably enough, the list does not include any *gakushū manga* in the strict sense. It consists solely of story-manga series such as Ikeda Riyoko's narrative *Berusaiyu no bara* (*The Rose of Versailles*, 1972-1973) about the French revolution, Nakazawa Keiji's Hiroshima tale *Hadashi no Gen* (*Barefoot Gen*, 1973-1985)²⁰, Takemiya Keiko's pioneering Boys Love narrative *Kaze to Ki no Uta* (*Poem of Wind and Trees*, 1976-1984), which aimed at sexual education, and – in category No. 9 called *Science/Learning* (*kagaku/gakushū*) – Ishikawa Masayuki's *Moyashimon* (*Tales of Agriculture*, 2004-2014).²¹

With a special focus on fermentation, *Moyashimon* approaches the world of microorganisms, and it introduces them in a 'characterized', but not necessarily anthropomorphized way (Fig. 16). The germs utter "*Kamosu zo!*" (*We will brew!*) and sometimes even "*Kamoshite korosu zo!*" (*We will brew and kill you!*) as in the case of *Escherichia coli* 0157:H7, the pathogenic bacteria invading the campus festival of the Tokyo University of Agriculture. Freshman Sawaki Tadayasu, the 'blond' guy in the black suit in Fig. 17 who warns everyone to not eat anything, can hear and see the microbial beings²² – and the manga reader with him. Just as Sawaki bridges two species, the narrative employs a twofold way of storytelling. Volume 8 of the series is representative in that regard. It begins with seven 'educational' pages exhibiting

¹⁹ Only the outline is available in English so far (last access: 20 June 2016). <http://www.nippon-foundation.or.jp/en/news/articles/2015/17.html>

²⁰ Called a 'documentary manga' by Kinsella (2000: 79) in disregard of the fact that its mode of address is neither documentary nor educational.

²¹ Serialized in the youth manga magazine *Evening*, 2004-2013, and subsequently in *Morning Two*, 2013-2014, republished in 13 tankōbon volumes, only two of which were officially published in English translation.

²² Whose made-up name provides the manga's title, a portmanteau of the words *moyashi* (lit. seed malt, rice malt; used also in the production of soy sauce, fermented soybean paste, and rice wine) + *mon* (abbr. *mono*: things, beings). Best understood as the plural form, which the Japanese language does not clearly indicate.

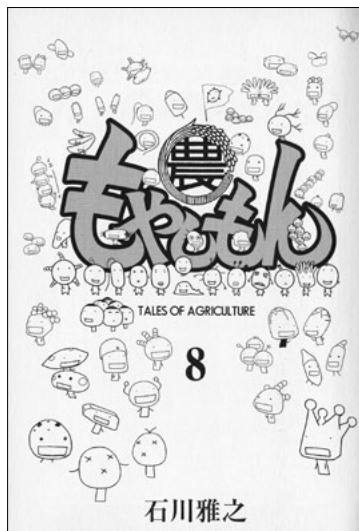


Fig. 16: Ishikawa Masayuki (2009): *Moyashimon (Tales of Agriculture)*, vol. 8. Tokyo: Kodansha. Frontispiece.

a low-key paneling and no central character to identify with. Here, the moyashimon assume the role of narrator to explain what beer is. They introduce different sorts (such as Pilsner, Ale, Lager etc.) and their ingredients, and they even touch upon the German, or more precisely Bavarian, purity law (annotated in the upper left margin of Fig. 18). Then the narrative mode changes to direct action, which also passes on knowledge but intradiegetically and through dialogue. While this may easily incur displeasure if the educational intent becomes all too obvious, *Moyashimon* averts the detriment by its often humorous focus on character interaction and the affects involved.²³

The main issue in volume 8 of *Moyashimon* is Japanese in comparison to European beer and, above all, Japanese craft beer in contrast to established Japanese brands. Graduate student Mutō Aoi, also known as 'Miss Agri U' among the students, stands in for the ordinary Japanese reader with her initial scepticism of microbreweries. After about 100 manga pages, in the course of which she meets a young female farmer who brews her own beer, Mutō reverses her judgment and organizes a craft-beer festival on campus, Agri U's own Oktoberfest. Having caught the influenza



Fig. 17: Ishikawa Masayuki (2005): *Moyashimon (Tales of Agriculture)*, vol. 1. Tokyo: Kodansha, pp. 192-193. [reading direction from right to left]

²³ Murakami/ Bryce (2009: 51-54) emphasize the similarity of *Moyashimon*'s two narrative modes with *rakugo*, a traditional art of humorous storytelling, in which the performer on stage plays the roles of both narrator and interacting characters.



Fig. 19: Ishikawa Masayuki (2009): *Moyashimon (Tales of Agriculture)*, vol. 8. Tokyo: Kodansha, p. 173.

3. Comics as Method

With respect to knowledge and education, comics tend to be treated as a 'container', i.e. a medium without agency, expected to serve the higher purpose. This tendency manifests itself in privileging representational content and verbalized, or verbalizable, meaning, even with regard to the pictorial side, for example, when critics praise manga for "spelling out the thematic focuses in the illustrations" (Murakami/ Bryce 2009: 50). As outlined above, the field of comics is anything but homogenous. Rather than discussing cultural differences – related to the receptiveness for consumer-related indeterminacy, flippancy, and conventionalization – this article has highlighted educational manga putting emphasis on entertaining serialized graphic narratives. The high-grade linkage of enjoyment and education which they perform has its limits. Their prevalence may, for example, go at the expense of documentary comics or comics journalism, genres not as prominent in Japan as in Europe and North America. In terms of quantifiable knowledge, Sugaya (2008) reports on an investigation which revealed that the story-manga type suits the cognition of nexuses rather than retrievable data and long-term rather than short-term memory. While the potential to attract readers via the power of affect is widely acknowledged, a distinct, comics-specific contribution to education is usually not expected or sought. But if it is true that "narratives of objective knowledge, universal truths, and the possibility of neutral representational practices have become subject to critical scrutiny, theoretical scepticism, and political pressure" (Mickwitz 2016: 20), then comics should be able to do more than support scientific monologizing, authenticity, and strictness. It seems time to conceptualize 'comics as method'. As distinct from the traditional assumption that educational comics just package and convey prefabricated educational content without affecting the content itself, 'comics as method' would mean to acknowledge comics' own potential for the formation of knowledge, for example, through the interrelation of affect and cognition, or imagination and rationalization. Educational manga are an interesting case to start with.

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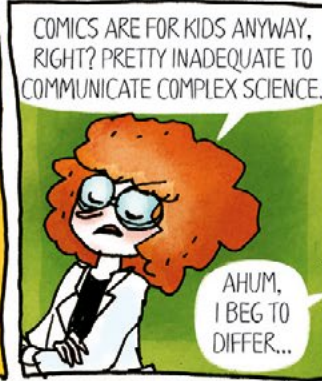
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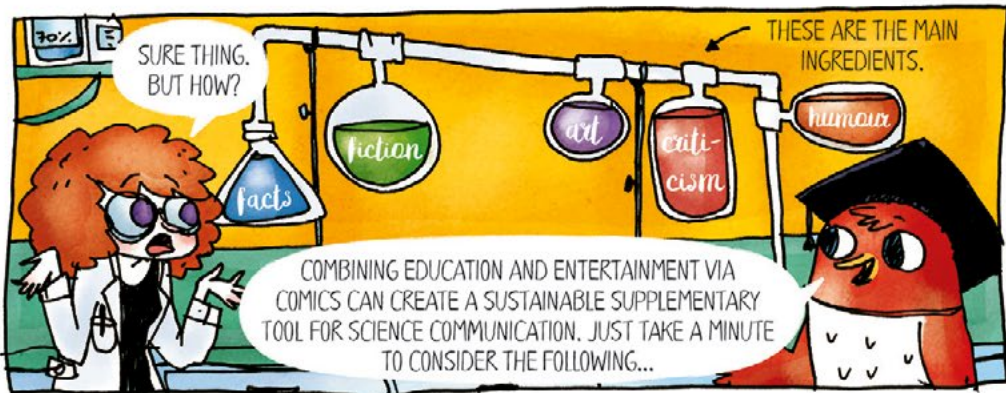
Veronika Mischitz is a freelance illustrator and comic strip artist. Her background in the natural sciences enabled her to specialise in science and knowledge communication. Her fields of work are visual development, communication, comics, and illustration. She designs non-fiction books, children's books, and picture books. She also offers drawing courses and draws live at events, readings, and concerts.

OH, COME ON!
SERIOUSLY?!

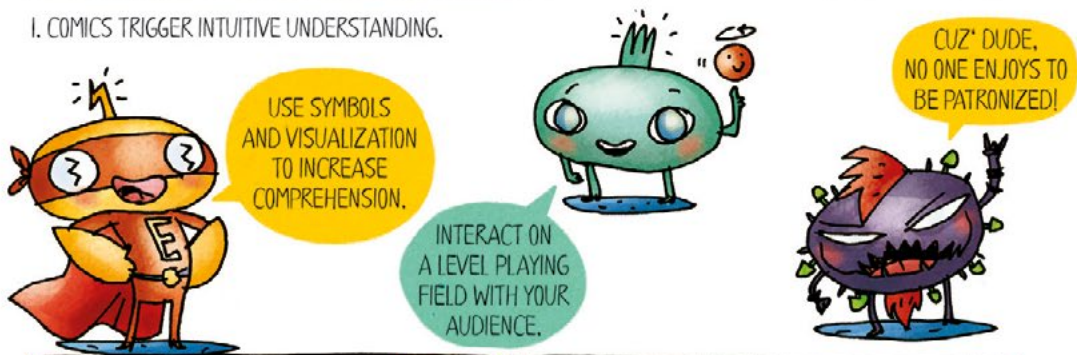
understanding science through comics



WOULDN'T IT BE AWESOME TO USE THE POWER OF STORYTELLING TO MAKE EDUCATION MORE APPEALING?



1. COMICS TRIGGER INTUITIVE UNDERSTANDING.



2. PEOPLE ARE INTERESTED IN PEOPLE.



3. IT'S OKAY TO HAVE FUN. DO YOUR RESEARCH WELL, BUT DON'T BE AFRAID OF THAT MAGIC MOMENTUM, THAT'LL TOP YOUR STORYLINE OFF...



IN OUR CASE*, IT DOES. COMICS OFFER A WIDE SCOPE. AND THERE'S ALWAYS SPARE ROOM FOR EXPERIMENTS.



* WWW.HELMHOLTZ.DE/COMIC

COMICS REQUIRE AN ACTIVE READER, WHO NAVIGATES THROUGH CAREFULLY COMPOSED IMAGES AND WORDS.



COMICS ARE ACCESSIBLE TO A LARGE AUDIENCE, INDEPENDENT OF PEOPLE'S EDUCATION AND BACKGROUND.

COMICS COMMUNICATE ON VARIOUS LEVELS SIMULTANEOUSLY AND INTUITIVELY.

IT'S WORTH A SHOT. HAVE FUN.



Science meets Comics



ROCCO



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Planetary Boundaries of Agriculture and Nutrition – an Anthropocene Approach

Introduction

Human-induced environmental change represents one of the major challenges of current and future generations. To evaluate the anthropogenic impacts on the biosphere, the concept of Planetary Boundaries (Rockström et al. 2009, Steffen et al. 2015) was developed, indicating that in case of four out of nine environmental indicators a transgression of corresponding boundaries has already taken place: Biodiversity loss, climate change, land-system change, and biogeochemical flows (N, P). Further, paleoclimate research has shown that the earth's environment has been relatively stable for the last 12,000 years (Walker et al. 2009, IPCC 2014). Researchers assume that this, in geological terms, very short period – called Holocene – is now already again replaced by a new geological era: the Anthropocene, due to the tremendous impacts humans had on earth (Crutzen 2002, Steffen et al. 2007, Steffen et al. 2011, Zalasiewicz et al. 2011). However, different views concerning the starting point of the Anthropocene exist – ranging from 50,000-10,000 BP with the first human-induced mega-fauna extinction to 1950, when, for the first time, persistent chemicals were produced globally in large scale (Lewis/Maslin 2015). A recently published article by Waters et al. (2016) provides new insights as stratigraphically distinct sediments were identified in drilling cores, supporting the hypothesis that the Anthropocene started in the middle of the twentieth century. The stratigraphically relevant substances identified by Waters et al. (2016), are mainly persistent chemicals and radionuclides.

However, to derive sector-specific political recommendations both concepts, Planetary Boundaries and Anthropocene, are too general. Therefore, we quantified the corresponding attributable fractions of the considered indicators in Rockström et al. (2009) and Steffen et al. (2015) related to agriculture and nutrition. Moreover, as the indicator atmospheric aerosol loading has not been quantified yet, we propose here a possible representation in the concept of the Planetary Boundaries. We focus here on the agricultural and nutritional sectors, as these are held to be responsible for major relevance affecting global environment change and degradation (Herrero et al. 2015, Kahiluoto et al. 2014, Lamb et al. 2016, Rosin et al. 2012, Smith et al. 2016). On the other side, shifts in agricultural and nutritional practices play a potential role to resolve current

problems (Foley et al. 2011, Meier/Christen 2012, Meier/Christen 2013, Nemecek et al. 2016, Tilman/Clark 2014, Vermeulen et al. 2012).

Method and Scope

For eight indicators covered in Rockström et al. (2009) and Steffen et al. (2015), we identified here corresponding attributable fractions related to agriculture and nutrition. Applying this sector-specific approach, we differentiate between agricultural production (agriculture), food processing and food trade (food processing/trade), and food consumption referring to household and gastronomy activities related to food preparation (food consumption).

Climate change

To account for the Planetary Boundary (PB) of climate change related to agriculture and nutrition, we used data from Bajzelj et al. (2013) and followed the approach of Rockström et al. (2009) and Steffen et al. (2015) considering solely CO₂-emissions. Emissions of CH₄ were omitted in this study. According to Rockström et al. (2009), emissions of N₂O are accounted for in the Planetary Boundary of the N cycle.

Biodiversity loss: Genetic diversity, extinction rate

To derive extinction rates (E/MSY) related to agriculture and nutrition, we used meta data from Hoffmann et al. (2011) indicating that 11% of all endangered species (possibly extinct) are attributed to agriculture and aquaculture, whereas 40% is attributed to hunting/trapping. Although we cannot exclude that endangered species are hunted also for nutritional purposes, the before mentioned 11% was used as a conservative proxy to derive the impact of agriculture on global species extinction. The impacts of agriculture and nutrition on Functional diversity / Biodiversity Intactness Index (BII) were omitted in this study.

Ocean acidification

As ocean acidification is mainly caused by the entry of atmospheric CO₂ into the sea, we applied as a proxy the corresponding share related to agriculture and nutrition identified by Bajzelj et al. (2013) for climate change. Hereby a linear correlation was assumed.

Biogeochemical flows (N, P)

Concerning the contribution of agricultural phosphorous use (P) to the global P cycle, we used data proposed by Steffen et al. (2015), who accounted globally for 14.2 Tg P yr⁻¹ which are applied via fertilizers to cropland – based on MacDonald et al. (2011) and Bouwman et al. (2013). The proposed regional agriculture-specific

P boundary of 6.2 Tg P yr⁻¹ was not considered in this study, as the overall impact should be analysed. Hence, the global boundary of 11 Tg P yr⁻¹ was used. P used in food processing was omitted from the study. With regards to nitrogen (N), we used the boundary proposed by De Vries et al. (2013) (62 Tg N yr⁻¹) and data from Kahilouto et al. (2014), which accounted for an N-uptake of 139 Tg N yr⁻¹ in agrifood systems.

Freshwater use

Using data from FAO Aqua Stat (2016), we identified a higher total blue water withdrawal of 3,721 km³ than Steffen et al. (2015) (2,600 km³) for the year 2005. Hence, assuming the same Planetary Boundary as Steffen et al. (2015) of 4,000 km³, the transgression of the boundary is far more within reach. Data from FAO Aqua Stat (2016) was also used to derive the amount of water withdrawal for agricultural and nutritional purposes (2,570 km³) related to the total water use – equaling a share of 68.9%.

Land-system change

Regarding the share of deforestation related to agriculture and nutrition, we used data taken from the comprehensive analysis of Hosonuma et al. (2012). They conclude that, overall, agriculture reflects 80% of deforestation worldwide.

Atmospheric aerosol loading

Using the global average concentration of particulate matter (PM_{2.5} with a diameter less than 2.5, PM₁₀ less than 10 microns, respectively), according to Apte et al. (2015) and WHO (2014), as well as corresponding WHO air quality guidelines (WHO 2006) as a proxy, we substantiate here, for the first time, this planetary boundary with robust data. Whereas Apte et al. (2015) used data from Brauer et al. (2012) referring to the year 2005, WHO (2014) builds upon data of the Ambient Air Pollution Database referring to the years 2008-2012. As planetary boundary, the WHO guidelines for the atmospheric concentration of particulate matter (WHO 2006) were used with an upper limit of 10 µg m⁻³ for PM_{2.5} and 20 µg m⁻³ for PM₁₀, respectively. With regards to the attributable fraction caused by agriculture, we used data from CEIP (2016) for the EU27, as data on global level was not available. In the EU27 in the year 2013, 12.7% of all PM₁₀ emissions and 3.3% of all PM_{2.5} emissions were due to agricultural activities.

Results

As presented in Tab. 1 and Fig. 1 current agricultural and nutritional activities contribute itself to the transgression of three planetary boundaries: the loss of biodiversity, biogeochemical flows (P, N), and land-system change. Whereas in the case of biodiversity loss, P cycle and land-system change, the transgression is in the zone of uncertainty – indicating an increasing risk (yellow marked fields in Tab. 1), the N boundary related to agriculture is more than 200% transgressed – indicating a high risk (red marked field in Tab. 1).

Agricultural and nutritional activities related to climate change and atmospheric aerosol loading alone do not lead to the transgression of the corresponding boundaries, but contribute indirectly to the transgression, whereas for climate change the relative impact is higher (37% compared to 8.9% in the case of atmospheric aerosol loading).

Although the indicators ocean acidification and freshwater use were close to 100%, the boundaries were crossed in neither case. Whereas for freshwater use with a total withdrawal of $3,71 \text{ km}^3 \text{ yr}^{-1}$ the attributable fraction of 69% related to agriculture is substantial ($2,567 \text{ km}^3 \text{ yr}^{-1}$), for ocean acidification the fraction had the same magnitude than for climate change (37%).

Due to missing data for food processing/trade and food consumption, no corresponding global impacts were calculated in this study for the following indicators: biodiversity loss, N and P biogeochemical flows, land system change, freshwater use, and atmospheric aerosol loading.

Impacts from food processing/trade and food consumption were solely considered for climate change and ocean acidification (see Fig. 1 and Tab. 1). Due to a lack of data in the case of stratospheric ozone depletion and novel entities, neither the impacts stemming from agriculture nor from food processing/trade and food consumption, were considered here.

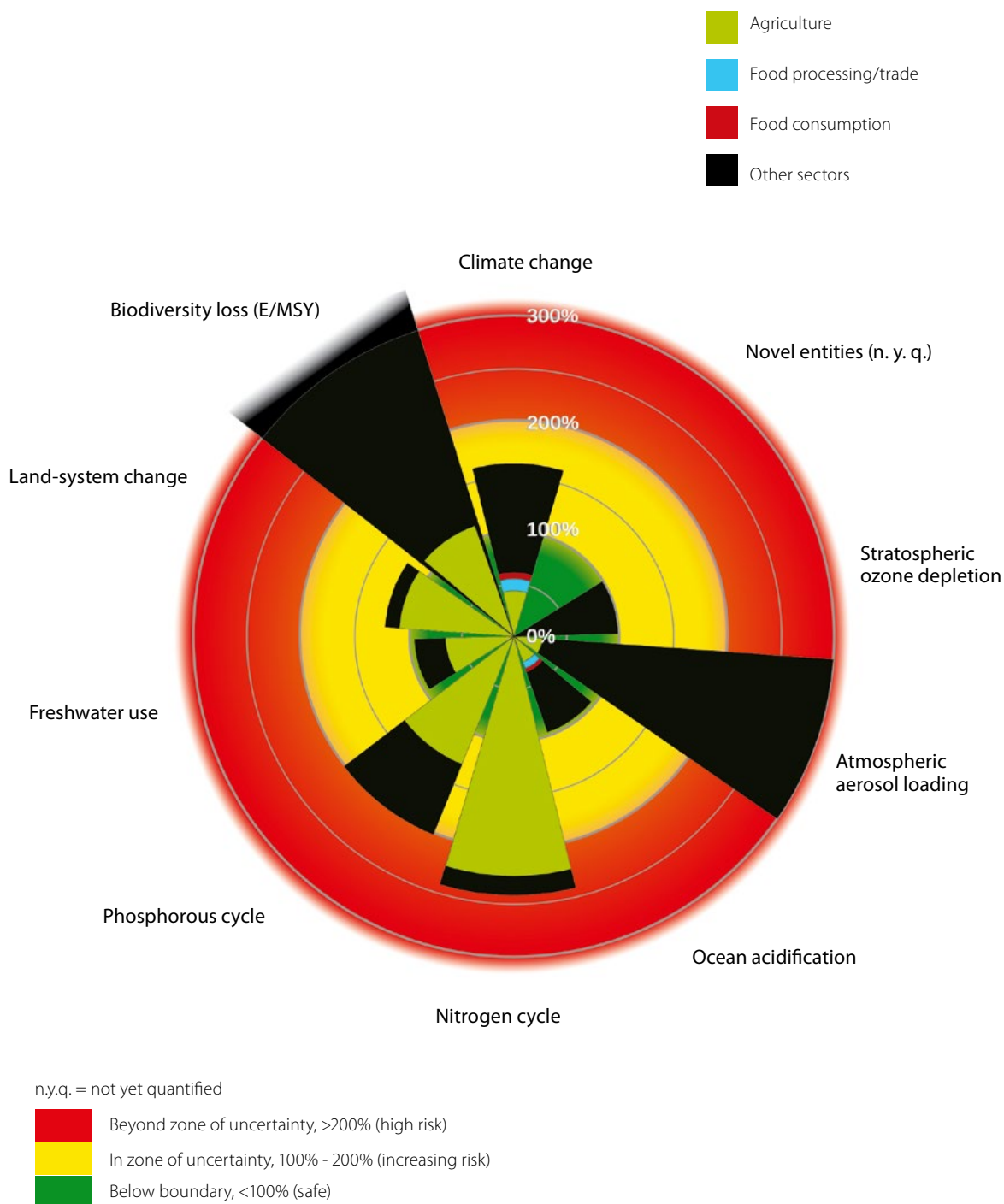





Fig. 1: **Fraction of agriculture and nutrition attributable to the total environmental burden and corresponding planetary boundaries.** The inner circle (green, <100%) represents the safe operating space for the planetary systems. The middle circle (yellow, 100-200%) represents the zone of uncertainty (increasing risk), whereas the outer circle (red, >200%) represents the zone with high environmental damage (high risk).

Tab. 1: Fraction of agriculture and nutrition attributable to the total environmental burden and corresponding planetary boundaries

earth system process / indicators	Parameters	Proposed boundary (zone of uncertainty)	Current status (total) <small>data source</small>	Current status (agriculture) <small>data source</small>	Current status (food processing, trade) <small>data source</small>	Current status (food consumption) <small>data source</small>	Pre-industrial level
Climate change	Energy imbalance at top of atmosphere (W m^{-2})	1 (1.0 - 1.5)	2.3 (1.1 - 3.3) 1)				0
	Atmospheric CO_2 concentration (ppm CO_2)	350 (350 - 450)	396.5 1)				280
	CO_2 emissions (Gt yr^{-1})	21,626	35,000 2)	9,283 3)	2,399 3)	1,316 3)	1,500
Biodiversity loss	Extinction rate, extinctions per million species per year (E/MSY)	<10 (10 - 100)	>100 1)	11 4)	?	?	0.1 - 1
Ocean acidification	Global mean saturation state of aragonite in surface sea water (Ω arag)	2.75	2.90 5)	0.77 3)	0.20 3)	0.11 3)	3.44
Stratospheric ozone depletion	Stratospheric ozone Depletion in Dobson Unit (DU)	276	283 1)	?	?	?	290
Biogeochemical flows	P cycle: P flow from freshwater systems into the ocean (Tg P yr^{-1})	11 (11 - 100)	~22 1)	14 1)	?	?	-1
	N cycle: industrial and intentional biological fixation of N (Tg N yr^{-1})	62 (62 - 82)	~150 1)	139 6)	?	?	0
Land-system change	Area of forested land as % of original forest cover	75 (75 - 54)	62 1)	70 7)	?	?	100
Freshwater use	Maximum amount of consumptive blue water use ($\text{km}^3 \text{ yr}^{-1}$)	4,000 (4,000 - 6,000)	3,721 8)	2,567 8)	?	?	415
Atmospheric aerosol loading	Particulate matter (PM 2.5) concentration in atmosphere ($\mu\text{g m}^{-3}$)	10	20 9)	0.7 11)	?	?	?
	Particulate matter (PM 10) concentration in atmosphere ($\mu\text{g m}^{-3}$)	20	71 10)	9.0 11)	?	?	?
Introduction of novel entities	No control variable currently defined	No boundary currently identified	?	?	?	?	?

	Beyond zone of uncertainty (high risk)
	In zone of uncertainty (increasing risk)
	Below boundary (safe)

- 1) According to Steffen et al. (2015)
- 2) Calculated by linear regression using data from Steffen et al. (2015)
- 3) Based on Bajzelj et al. (2013) (reference year: 2010), without N₂O emissions, as these emissions are accounted for in the N cycle
- 4) According to Hoffmann et al. (2011), related to endangered species (possibly extinct) due to agri- and aquaculture (reference year: 2008)
- 5) According to Rockström et al. (2009)
- 6) According to Kahiluoto et al. (2014)
- 7) According to Hosonuma et al. (2012)
- 8) According to FAO Aqua Stat (2016) for the year 2005
- 9) According to Apte et al. (2015), lognormal distribution, geometric mean of PM_{2.5}
- 10) According to WHO (2014) for the period 2008 - 2012
- 11) According to WHO (2006)

Discussion

The originality of our study is based upon the consistent integration of agriculture and nutrition-related environmental pressures into the concept of Planetary Boundaries. With the exception of stratospheric ozone depletion, the corresponding attributable fractions were identified and included. To the best of our knowledge, a similar approach was solely applied by Kahiluoto et al. (2014) considering the impact of agriculture and nutrition on global N and P cycles. In comparison to Kahiluoto et al. (2014), different results were identified for the agriculture-related share of the P cycle. Whereas Kahiluoto et al. (2014) based their assessment on data from Seitzinger et al. (2010), we used here data from Steffen et al. (2015). Further, it has to be mentioned that in case of uncertain attributable fractions (biodiversity loss) the most conservative value was chosen to be implemented in our analysis. In case of biodiversity loss, therefore, the attributable fraction related to agriculture might be even higher.

Conclusion

Taking the production, processing and trade of food, as well as food consumption into account (here referred to as agriculture and nutrition), we could show that in case of three out of four critical indicators (biodiversity loss, biogeochemical flows (P, N), and land-system change) the latter are predominantly affected by agricultural activities. The strongest contribution to a transgression of a planetary boundary at all, was caused by the excessive application of nitrogen (N) as fertilizer in agriculture. Moreover, as the application of N is related to other critical indicators indirectly – via the emissions of N_2O to climate change and via eutrophication to biodiversity loss (Storkey et al. 2015, Tilman/Isbell 2015) – the ban of an excessive usage of N should be prioritized in agricultural policy agendas.

Further, additional efforts should be made to quantify the current status as well as the planetary boundary concerning the release of novel entities – by Rockström et al. (2009) described as chemical pollution. Although both concepts, the one of the Planetary Boundaries and the one of the Anthropocene, are closely interwoven, this parameter, which represents the core rationale behind the concept of the Anthropocen (see introduction), is currently not substantiated with robust data in the concept of the planetary boundaries. Moreover, further studies should focus on the data gaps identified related to food processing/trade and food consumption (see results) and implement this data properly in the framework of the planetary boundaries.

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Arnold van Huis

Insects, the New Food?

Introduction

In many parts of the world it is common to eat insects while in the western world it is regarded as a bizarre habit, even evoking disgust. Is this justified? What if insects were nutritionally similar to our common meat products and have proven to be delicious in blind tests? Insects have an environmental impact which is much less than our common production animals, so why not eat it? If these questions can be answered affirmatively, then the question is: Can we persuade the western consumers to take this psychological barrier? There has been a tremendous interest during the last five years to promote insects as food. There are now close to 200 start-up companies listed (Bugburger 2017). Also, in the scientific world the interest is growing exponentially, testified by the number of articles on edible insects that have appeared during the last 15 years (83 from 2011 to 2015 against 9 from 2001 to 2005¹). These articles deal with harvesting from nature, environmental benefits, nutritional value, food safety, processing, and consumer attitudes. I will give a short overview of the developments in these different areas.

From harvesting in nature to rearing

Edible insects in the tropical world are collected from nature, often in forests, and have therefore been termed 'non-wood forest products'. Why in the tropics and not in temperate zones? Very likely because insects in the tropics are larger in size, and are – in the absence of a winter – available throughout the year. Also, they often occur clumped, thus facilitating harvesting. In Mexico, the grasshopper, *Sphenarium purpurascens*, is a pest of maize and beans. However, since prehistoric times this species, locally called 'chapulines', can be handpicked instead of using pesticides, and provide hundreds of tonnes of food for human consumption (Cerritos et al. 2015).

It has sometimes been erroneously suggested that people in the tropics eat insects because they are starving, i.e., using it as a survival strategy. However, insects on local markets are often more expensive than common meat products indicating that they are considered delicious. This was demonstrated in early 2016 by a BBC documentary in Cameroon where the demand for palm weevil larvae was soaring because demand outstripped supply (Ford 2016). The solution proposed in this

¹ Web of Science searching for 'edible insects' (accessed Feb. 2017).

country was to rear them on pieces of raffia palm in plastic boxes increasing harvest by 8 to 10 times. When promoting insects as food, rearing or farming, insects are a solution. In Thailand, crickets are favoured food and although there are 20,000 farms producing more than 7,500 tonnes a year, the demand is so high that crickets from neighbouring countries are imported (Durst/Hanboonsong 2015, Hanboonsong et al. 2013).

So when promoting insects as food, the animals need to be farmed, and that is why reared insects are referred to as mini-livestock. Mealworm larvae are reared in trays, crickets in plastic containers, and grasshoppers in cages. This requires quite some labour, which is why the price for the latter is often still too high. So companies are now investigating how to automate production processes. Also, the substrate on which the insects are reared receive attention as, in principle, it would be possible to rear the insects on organic side streams.

Nutrition

Are insects nutritious? This question is difficult to answer because we are talking about more than 2000 different species. Also, the nutritional value depends on many factors, such as rearing conditions, the diet, and in which stage the insects are harvested (Finke/Oonincx 2014). Even processing has an influence on nutritional quality. Then, the analytic methods used to determine the nutrients are also of importance. But generally speaking, many edible insect species provide satisfactorily with energy and protein, meet amino acid requirements for humans, are high in mono and poly unsaturated fatty acids, and rich in several micronutrients (Rumpold/Schlüter 2013). One study even showed that crickets, palm weevil larvae, and mealworms had a significantly healthier Nutrient Value Score than beef and chicken (Payne et al. 2015).

Why insects?

Why should we replace our current meat products by insect products? One answer would be 'out of necessity' to satisfy the increased demand for meat. This may be not so much in the case for the developed countries where meat consumption per capita from 2010 to 2050 will remain similar (Europe at 72 kg) or declines (USA from 110 to 95 kg), while in Africa and Asia it will increase from 17 to 28 and 32 to 48 kg, respectively (Revell, 2015). On a global scale this means an increase of 66% from 287 to 476 million. But 68% of all agricultural land is already under permanent pasture (FAOstat 2013, consulted March 2016), while about one third of all cereal production is used as feed for livestock (FAO 2002). This amount would be able to feed 3 billion people (Eisler et al. 2014). So, in order to meet future meat demands, we

need alternative protein products. A study on land use for producing protein from mealworms indicated that much less land was required than that from chickens, pigs, and cattle (Oonincx/Boer 2012).

Also livestock is responsible for more than 14% of global greenhouse gas emissions (Gerber et al. 2013), while, for example, mealworms produce much less (Oonincx/Boer 2012). It has been estimated that for producing one kg of beef up to 43,000 liters of water may be required (Pimentel et al. 2004). In a study comparing mealworms with chicken, pork, and beef it was shown that the amount required for producing mealworms was 23 liters per gram of protein, while for chicken, pigs, and beef it was 1.5, 2.5 and 4.9 times as much (Miglietta et al. 2015). The efficiency of the insect to convert feed into edible body weight is much higher than that for the animals: Crickets turn 2.1 kg of feed into 1 kg of edible body weight, while the production of one kg of edible body weight of poultry, pork, and beef requires 4.5, 9.1 and 25 kg, respectively (van Huis 2013) (Fig. 1). This is very likely so because the cold-blooded insects do not need to feed in order to maintain a body temperature. There is one other advantage of producing insects over the common production animals. Insects can be reared on remains of fruits and vegetables, as was shown by Ramos-Elorduy et al. (2002) for mealworms. However, food safety issues need to be considered.

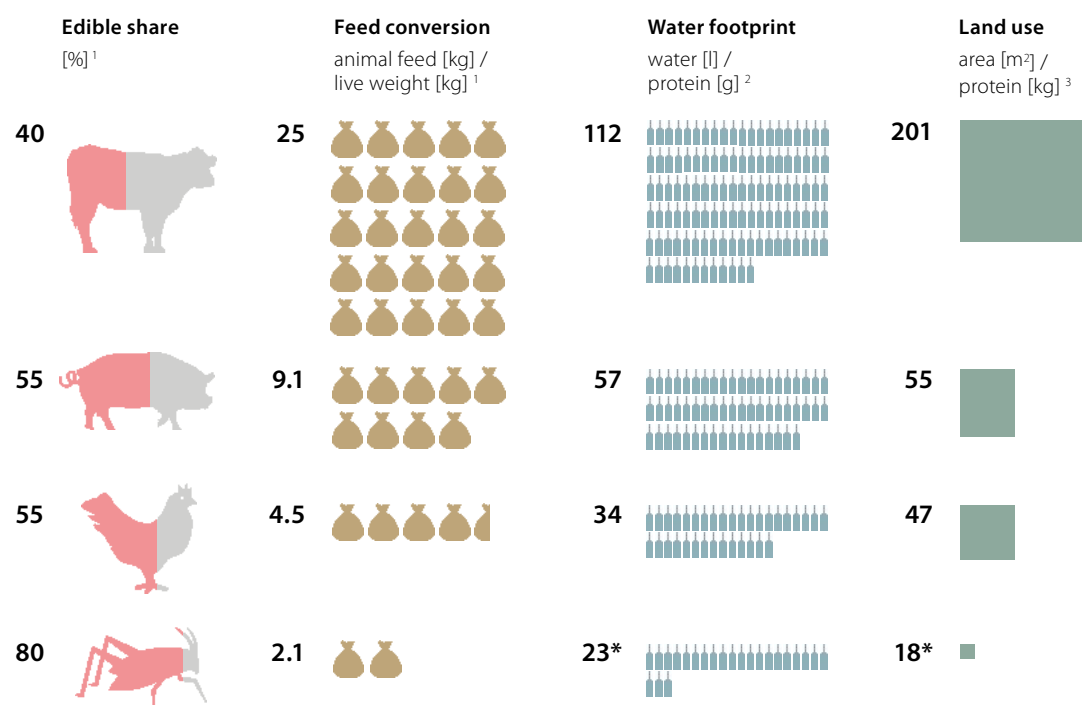


Fig. 1: Ressources needed for each produce: (1) van Huis 2013, (2) Miglietta et al. 2015, (3) Oonincx/Boer 2012. Schleunitz/Kirstein [eds.], after van Huis (2013), *data collected for mealworm.

Food safety

Insect species are invertebrates and very distinct from vertebrates. Therefore, the pathogens associated with insects do not pose any risk to humans (Eilenberg et al. 2015). That does not mean that insects cannot become diseased. Insect rearing companies are sometimes confronted with diseases that may have a serious effect on insect colonies. The house cricket, *Acheta domesticus*, for example, is highly susceptible to a densovirus which can decimate commercial rearings of crickets (Szelei et al. 2011). Also, the Korean horn beetle, *Allomyrina dichotoma*, used in Korean medicine, suffers from a viral disease, and became a devastating threat for the insect industry (Lee et al. 2015). However, these viruses are not dangerous to humans; some toxic edible insects are eaten. In southern Africa an edible stinkbug (*Encosternum delegorguei*) is considered a delicacy and analysis indicates good nutritional value. However, they secrete a defence chemical that stains skins, and stings eyes such that it may even cause temporary blindness. Some ethnic groups use a method in which water is used to remove the chemical before they consume the insects. In Malawi, this water is afterwards used as a termiticide (Dzerefos et al. 2013).

Problems may arise if insects are not properly processed. For example, the mopane caterpillar, very popular food in southern Africa, is collected, cooked in water, and then dried on the soil by the sun. However, they may pick up pathogens when dried on the bare soil. When insects are commercially reared, hygienic conditions during production are important as contamination is the main food safety risk. There is, however, a risk for people allergic to house dust mite and seafood. Because insects and crustaceans are taxonomically very close, cross reactivity may occur. Even processing, such as an heating step, does not eliminate that risk, as has been shown for three mealworm species (van Broekhoven et al. 2016). This is why insect products should indicate this risk on the label. If insects are reared on organic side streams, then there may be a risk if it contains biological or chemical contaminants. Therefore, certified clean organic by-products should be used.

Insects as feed

For fish, pigs, and chickens insects are natural feed. In the tropics local farmers collect whole or pieces of termite hills and break them in order to feed their chickens, chicks, or guinea fowls. In Asia you often see night lights above ponds in order to attract insects which fall into the water as fish feed. Nowadays, there are companies that produce tonnes of insects a week as feed for animals. Most popular is the black soldier fly (*Hermetia illucens*), which naturally occurs in manure and can easily be grown on organic side streams (Tschirner/Simon 2015). It is used as fish feed and pet food. If it would be used for pigs and poultry, then we are talking

about more than 70% of the feed for animals used in the world, and this market represents more than US\$ 300 billion (Alltech 2016). However, in the European Union, the black soldier fly is not yet allowed as feed for pigs and chicken. This was due to the incidence of the mad cow disease, after which it was decided that animals were not allowed to be fed to animals. However, nobody realized at that time that insects are also animals. It is extremely unlikely that insects would pose a threat – in particular when certified clean substrates are used, which do not contain remains of ruminants.

Insect products

In several tropical countries there has been experimenting with insect products (Fig. 2). For example in Mexico, tortillas supplemented with 7% yellow mealworm (*Tenebrio molitor*) larvae powder had excellent consumer acceptance (Aguilar-Miranda et al. 2002). The powder contained 58% protein, rich in essential amino acids, such as phenylalanine, tyrosine, tryptophan, and high contents of the fatty acids oleic acid and linoleic acid. In Korea, muffins containing up to 8% mealworm powder had acceptable sensory properties, such as flavour, taste, and overall acceptability (Hwang/Choi 2015). In Kenya, ground edible winged termites (*Macrotermes subhylanus*) were incorporated in baked food products. Wheat-termite buns at 5% substitution were well accepted by consumers with no difference with the control for texture, aroma, taste, and overall consumer preference (Kinyuru et al. 2009). The 5% substitution showed a significant increase in protein, retinol, riboflavin, iron, and zinc contents. In the Democratic Republic of Congo, a cereal was made from caterpillars in order to study whether it could reduce stunting and anaemia in infants (Bauserman et al. 2015). Stunting was not reduced but infants in the cereal group had higher hemoglobin concentration than infants in the control group and fewer were anaemic.

In the western world the interest in edible insects is also growing. Most popular are different cricket species, in particular the house cricket and several mealworm species which are larvae of beetles that naturally occur in stored grains. The insects can be bought as a whole, often freeze dried. However, mostly the insects are processed into flour and then incorporated in products. The products are protein bars, cookies, and pasta. But they can also be incorporated into familiar products such as burgers, schnitzels, meatballs, and nuggets. In some countries like Belgium and The Netherlands they can be bought as such in the supermarket.

Insects as food for over 2 Billion people

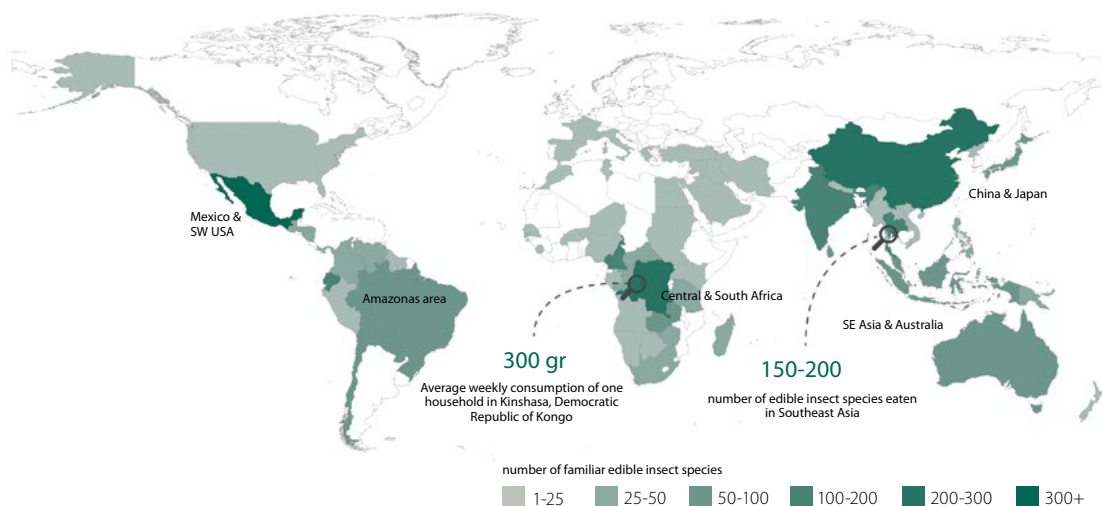


Fig. 2: Familiar edible insect species worldwide, after Jongema (2014)

How to convince consumers?

There are a number of strategies that have been proposed to increase consumer acceptance. The most important one is to incorporate the grinded insect into familiar products such as burgers, muffins, etc. as mentioned above. Another strategy are the so-called 'bug banquets' in which the consumer has the possibility to taste the product and become familiar with it (Looy/Wood 2006). These events are often organized during food fairs. It is of course important to provide information and stress food safety, nutrition, and environmental benefits. Role models are important, e.g. in *The Insect Cookbook* an interview was incorporated with the former secretary-general of the United Nations, Kofi Annan, who indicated that consumer acceptance is just a question of education (van Huis et al. 2014). In the same book there was an interview with René Redzepi, whose restaurant Noma, was voted to be the best restaurant in the world from 2010 to 2012. He believes it is a "racial thing" that western people do not consider eating insects, because it is from cultures in developing countries; a primitive habit. To convince consumers, it is also important to stress the proximity with crustaceans. For example, edible locusts have been called 'sky prawns' in Australia.

Conclusion

Eating insects is a new concept in the western world, and in order to promote it, the cooperation between disciplines, such as food and nutrition, entomology, agriculture, environmental science, and consumer science, is needed. Because the

topic has been neglected for so long, more information need to be collected of how insects are harvested, prepared, consumed, and marketed in tropical countries. Also, the information in agricultural and food databases is notoriously absent. Recently, FAO/INFOODS collected and published analytical data from primary sources with sufficient quality in the Food Composition Database for Biodiversity (INFOODS 2012). There is still quite some work to do to determine the nutritional value of the 2000 insect species that are eaten. Considering the environmental impact of farming edible insect species, we only have information about mealworm production (Oonincx/de Boer 2012), that is why more studies are urgently needed. In particular, the rearing of edible insect species on organic side streams is interesting and may contribute to achieving a more circular economy. Of course, then, the study of food safety need to be considered, in particular how insects deal with biological and chemical contaminants. The private companies are currently investigating how to automate the production process in order to reduce the cost price. However, all this is not enough. In order to convince the consumer, insects should be made delicious, and this is an important challenge for the cooking industry.

Insects have a lot of potential in food and feed production. It is on its way to become a new agricultural and food sector. Despite the recent interest in this topic worldwide, we are still at a preliminary stage and a lot of effort is needed, by private and public partners, to realize its potential.



Photo by Jens Kirstein

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Food Production in the Anthropocene: The Role of AgTech in Urban Spaces

Our daily food consumption is slowly but surely turning into the largest environmental threat. The agricultural sector consumes 70% of the water used by humankind (Fox/Fimeche 2013). The production of meat consumes enormous amounts of water compared to plants. For example, a single kg of beef takes roughly 15,500 liters of water to produce (Fox/Fimeche 2013), as opposed to 2,000 liters for a kilogram of soy (Ercin et al. 2011). Estimates show growth rates of roughly 20% per decade for meat demand – while population growth has slowed to around 10% per decade (Rabobank 2011). Especially the growing middle classes of emerging countries demand for more sophisticated food – in other words, animal proteins. Today, livestock production uses up to 75% of the agricultural land; one third of the cereals produced is fed to livestock (Steinfeld et al. 2006) – which then need up to 30 calories to produce one calorie of meat. Fish would seem an obvious alternative here, as many fish have much better 'feed-conversion-ratios', in other words, they need as little as 1 kg of feed to produce 1 kg of fish (Lane et al. 2014).

However, overfishing has decreased fish populations worldwide by 50% in the past 40 years (World Wildlife Fund 2015). That means we have eaten half the fish from the oceans, plus all the new fish reproduced in 40 years, plus the fish produced in aquaculture, which today makes up half of all fish consumed annually (FAO 2014). And fish only makes up 20% of the animal meat eaten. As a consequence, 70 to 85% of fisheries are at or beyond biological limits. Millions of people, especially those living in coastal areas, depend on fishing for their staple food and livelihoods. 'Modern' aquaculture also comes with many problems, ranging from hormones to environmental impact, such as the destruction of mangroves, or the eutrophication of waters (Lane et al. 2014).

Worse yet, around 40% of all foodstuff never reaches the supermarket (Fox/Fimeche 2013). In future the number of people, and therefore consumers, living in cities and so-called megacities, will rise to 70%. Food production, on the other hand, is located in rural areas. Add globalization and the fact that many of us today ask for all foods all year round (instead of making seasonal choices). As a result, food is being shipped large distances before consumption – and especially in low-income countries, a lot of it perishes en route due

to pathogens, fungi, or insects. But our Western standards (overpurchasing) and perfectionism habits are also a major problem (FAO 2015).

With one billion malnourished people on the planet, in other words 15% of all humankind, we can't afford to lose so much food. 40% wasted food at a value of 750 billion USD sounds like an easy solution to feed even 9 billion. Unfortunately, the answer is not that simple. Besides preservation problems, there is another limitation.

Degradation of soil affects one third of Earth's land surface and 40% of all arable land today (Arsenault 2014). Over the past 150 years, half of our topsoil has been lost due to erosion, compaction, loss of soil structure, nutrient degradation, loss of carbon, and soil salinity (World Wildlife Fund 2016). At the current rate, we have about 60 years of topsoil left (Arsenault 2014). Due to growing populations and consumption, natural resources have become object to speculation, the land being used for mining, buildings, and streets rather than farming. And most likely, climate change will provoke extreme weather conditions, reducing crop yields on the arable land that remains – which will lead to increasing food prices and more people seeking refuge from poverty and hunger.

To sum up, the challenge is immense: With tastes changing, we need to produce 50% more food from soil producing up to 30% less with oceans at more than their limit (World Bank 2016).

Sustainable solutions need to address all three challenges – and should make use of urban spaces as part of the solution. There are dormant areas, empty buildings, or unused basements and rooftops which can be used for small-scale food production that can still be profitable. According to calculations by Fraunhofer Institute (Keuter/Krause 2011), Germany could produce all vegetables it consumes on 36,000 ha of German rooftops.¹

Innovations in the area of food production are lately summarized as *AgTech*, agricultural technology. This encompasses all sorts of areas, ranging from drone-controlled tractors to printed hamburgers. Specifically the challenge of making use of the limited areas available in cities and maximizing crop yields has seen a recent boom in novel approaches – and quite a bit of investor finance.

¹ Germany needs 120,000 ha of vegetable production; Fraunhofer assumes higher annual yields in rooftop greenhouses. Even better, roughly 250 m² are needed to produce and process 50 tonnes of fish p.a. Germany consumes roughly 1.3m tonnes of fish, so 2% of all rooftops would theoretically be sufficient to cover the entire German demand for fish.



Fig. 1: Design of urban rooftop greenhouse with integrated vertical farming

Done right, food production using urban spaces can fulfill numerous criteria:

- Conservation of resources
- (Almost) free of emissions
- Copying natural ecosystems
- No use of drugs, pesticides, fungicides, insecticides, hormones
- Combining sustainability with efficiency
- Powered by renewable sources (biomass, solar)
- Production close to consumption

Let me present some examples of what is already being implemented today.

There is a wide range of non-commercial projects and initiatives around community gardening. Groups of neighbors or other people use undeveloped and rundown spaces to cultivate fruits and vegetables, and many of these gardens are a sight to sore eyes in the city gray. Dozens of cities around the world are host to beautiful and inspiring examples of this, which play a valuable role in our societies, connecting people, preserving seeds of traditional varieties, and building and strengthening communities and neighborhoods. Lacking a business model, nearly all of these initiatives rely on the involvement of committed individuals. Yet, without financial sustainability, many projects are of a temporary nature. There have been waves of community gardening in the past, Germany saw much of that in the 1970s. So despite the service community gardening does to our cities, it does not play a role in solving the food crisis.

Several companies around the globe have begun implementing commercial rooftop farming. Nearly all produce greens and vegetables, many in summer season, some all year round in greenhouses, delivering restaurants and retailers in their neighborhood. Other companies cultivate greens inside buildings such as empty factories and underground spaces or containers using LEDs and controlling climatic conditions. Here again, greens are the focus, often even medicinal plants or micro-greens, as fast growth and high prices are needed to cover the cost of the high-tech production.

And the past years have seen a boom in home-growing hydroponic systems. These are small-scale, remote-controlled, automatically fed, watered, LED-lighted plant growing systems, many of which engage consumers by displaying vitality data of the plants on mobile phones, very much creating a tamagotchi effect for city dwellers. But compared to the price, they are inefficient and produce very little.

All three examples tend to require artificial fertilizers – and none of them produce meat, which is still the major challenge. A hybrid solution (producing animals AND plants) that has been hyped recently is *Aquaponics*.

Aquaponics systems have been around for thousands of years. From the ancient world, systems have been passed on that enabled a natural cycle of fish and plant cultivation. Aquaponics describes a method of rearing fish in aquaculture and combining this with the cultivation of agricultural crops. Today, these are most often grown in containers with substrates such as foamed clay or gravel and receive water enriched with nutrients from fish excretions. These substrates generally fulfill a support function, salads are often produced just in water. Regulation of nutrients for optimal growth of the plants is achieved by separating the water cycles between fish and plant production and adding artificial fertilizer for the plants as needed. Aquaponics is argued to be more systemic than traditional agriculture.

However, food production is only truly sustainable if it consistently mimics ecosystems, in other words actually cascading resources, and drastically reduces the land usage per head. That is why a Berlin team has developed a system they call *Aquaterraponics* which leads the water full cycle and reintroduces soil as an element for healthy and integral plant growth. The method uses all material flows and excess nutrients to grow plants (including duckweed and algae, both of which are extremely rich in proteins). The biomass that cannot be used in this way is fed to insects, which serve as feed and another vital source of protein for the fish. In this system, a significant amount of the feed needed can be self-produced, and all

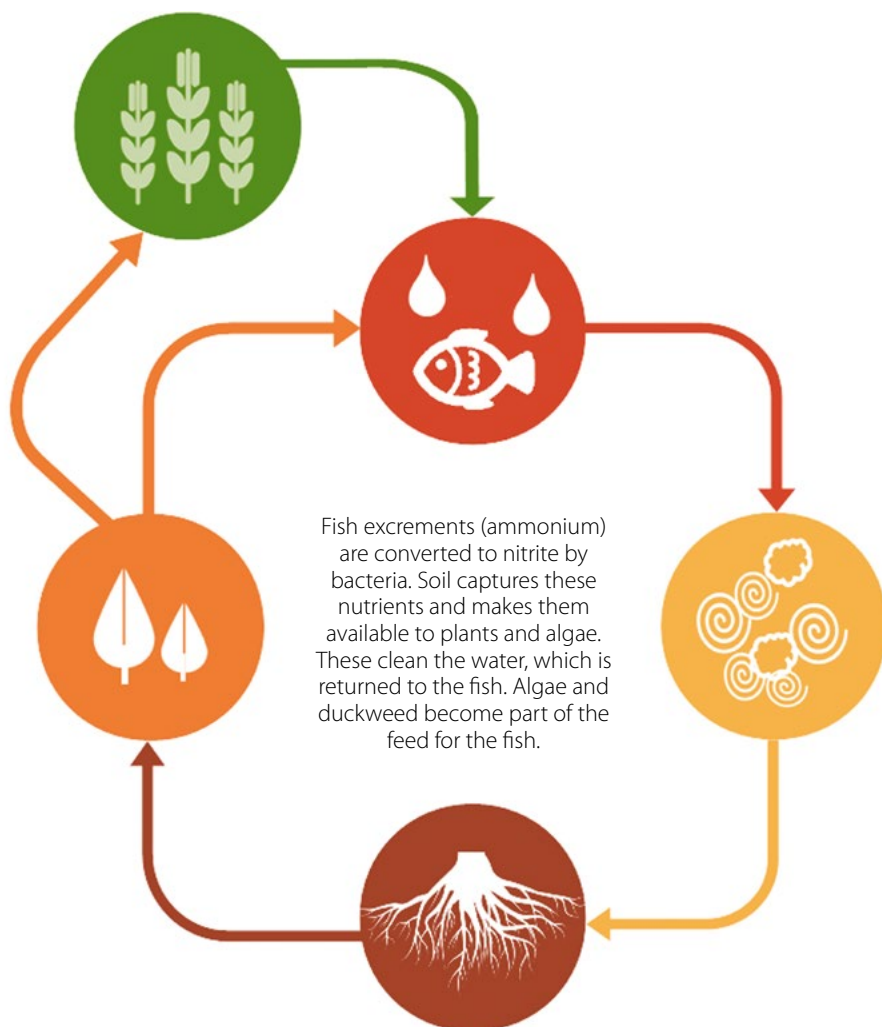


Fig. 2: Schematic illustration of biology in aquaterraponic system

fish meal eliminated from fish production. This is not just ecologically sensible – it also reduces the cost pressure that the fish market has seen due to soaring fish meal prices.

Add to this the possibility of operating these systems with renewable energy, but also utilizing residual heat from district heating wherever possible. A modular container system makes it possible to move parts of the production to other locations or expand without lengthy administrative processes. And despite its complexity, Aquaterraponics systems can be operated profitably on comparatively little space, roughly 1,000 m² is enough – an area that can often be found within cities or in their absolute vicinity. The aim of Aquaterraponics is uncompromising sustainability that is financially viable.

Aquaterraponics can produce fish for 1,800 Europeans and vegetables and fruits for 90 on every 1,000 m² of space. That is roughly ten times the regular space productivity for plant produce and one third of the space needed compared to conventional meat production. In Germany, 2,500 m² of agricultural land is needed per head to produce our food – most of this space is 'imported'. Planet-friendly would be 1,300 m². Using Aquaterraponics on unused spaces to grow our animal protein and vegetables, this number can be achieved, even if milk, eggs and cereals are still produced as they are today. Of course, this is a theoretical calculation, but it shows the potential the right AgTech methods can have producing on urban spaces. The reduced impact of less logistics and less wasted food, as the harvest reaches consumers within miles rather than days in airplanes, ships and trucks, is not even included in that calculation.

Naturally, every technology can be misused or applied 'wrongly'. A high level of biodiversity is preferable and important to maintain the stability of Aquaterraponics systems, since plants need to strengthen and protect their so-called companions (beneficial species) rather than pesticides. More monocultures and genetically manipulated varieties would not be a desirable path – not least since old varieties of tomatoes, salads, and herbs have proven to flourish better in the Aquaterraponics near-natural ecosystem than new breeds. Not least, the aim must be to keep solutions as low-tech as possible to reduce investment costs – and create jobs instead.

Over the past century, our cities have forgotten how to integrate different functions: Working, living, and production have become separated into distant areas, we spend a lot of our time commuting from one to the other. During the time of the wall, West Berlin was different, as space was so limited that special programs encouraged the stacking of functions into a harmonic system. At least food production should be able to rediscover that way of city life, when implemented sustainably it can even reduce emissions and improve quality of life. Inhabitants become aware again of agriculture and food production, giving them more importance than before. High quality (freshness!), transparency, and renewable energy become features that are demanded rather than wishful thinking.

When food production moves back into the cities, both existing structures as well as new buildings can be used – and city development should be thought in a way to integrate this element of our lives into the vicinity of our living quarters, rather than banning it to industrial estates. Cities that harmonize sleeping, recreation, work, and transport, and generate a balance of these functions, generate a multitude of benefits for their inhabitants.

How do we get to a world where urban spaces are utilized in such a manner? There are three approaches:

- Rules and regulations
- Education & consumer campaigns (changing behaviors)
- Business models without collateral damage

I personally believe in the latter as a driver towards fast change, with numerous social entrepreneurs today simply waiting for opportunities to emerge.

Healthy ecosystems supply us with an abundance of healthy foodstuffs. We all should appreciate food and its producers more. Those who bring their groceries home climate neutral by bike or on foot and know how and where it was produced can savor fish and meat again with a clear conscience.

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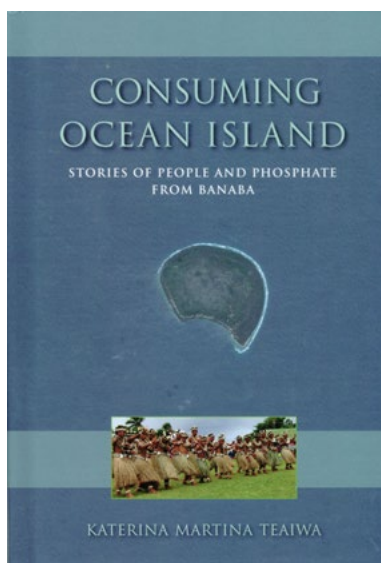
Dr. Katerina Teaiwa was born and raised in Fiji and is of Banaban, I-Kiribati, and African American descent. She is Associate Professor in the School of Culture, History and Language, College of Asia and the Pacific at the Australian National University in Canberra. She is also President of the Australian Association for Pacific Studies. From 2011 Katerina has been a Research Fellow in *the Framing the Global Research and Publication Project* at the Center for the Study of Global Change at Indiana University. She is the author of *Consuming Ocean Island: Stories of People and Phosphate from Banaba* (Indiana University Press 2015).



Dr. Teresia Teaiwa is an award winning scholar and mentor, and the founder of Pacific Studies at Victoria University of Wellington. She is currently Director of Va'aomanu Pasifika which includes Pacific Studies and Samoan Studies. A practising poet, Dr. Teaiwa is also researcher and author of numerous articles and book chapters on history, art, politics, gender and militarism in Oceania. She interviews a variety of Pacific women activists, authors and artists on her *microwoman blog* (microwoman.wordpress.com).

Katerina Teaiwa

Interview with Katerina Teaiwa by Teresia K. Teaiwa for Microwomen



Katerina Teaiwa (2015): *Consuming Ocean Island: Stories of People and Phosphate from Banaba*, Indiana University Press. Cover

Microwoman: Congratulations on the publication of your book, Kat! How long did it take you to pull it all together?

Katerina Teaiwa: Oh, hello, big sister, thank you!

I began historical research on Banaba in 1997 as part of my Master's at the University of Hawai'i (UH) and continued from 1999 at the Australian National University (ANU) as a Ph.D. scholar in anthropology. I was very inspired by your work and early writing about contemporary Banaban identities and, as you know, Dad became a key interlocutor and provided much support for my work. This was always a family project, even when I was in a more academic or analytical mode.

I finished my Ph.D. in 2003 after lots of archival research and fieldwork (I called it 'homework'), and then took a break while I taught at UH for 3.5 years. I then dived back into archival work at the Macmillan Brown Centre for Pacific Studies at the University of Canterbury in Christchurch in 2006. John Macmillan Brown had shares in the phosphate company in the early 1900s.

I had to take another break after I began a new job at ANU in 2007 with a few trips to the archives every year and visits to Rabi in Fiji. I had also collected many hours of film footage and archival photographs, and



Dr. Katerina Teaiwa, Dr. Teresia Teaiwa and younger sister, Dr. Maria Teaiwa, 1977

transformed some of these into short visual studies and collaborated with artists and curators to share this history in visual and multimedia forms. Finally, in 2010 I began to reimagine this as a book proposal and finalized that in 2011 while on a fellowship at the University of Rochester in New York. Thus began the task of taking apart my Master's and Ph.D. research, reconstructing parts I could use in a book and writing five new chapters. This took almost two years and it went through a long process of feedback from three reviewers, and three editors at Indiana University Press in the same period. The challenge was to write this story for a wider audience and particularly American readers who are unfamiliar with Oceania and Pacific studies.



Banaban dancers, Ocean Island, 1901. Courtesy of the National Archives of Australia

I think reimagining the book in this way made it better but it was a long, challenging process. For a 4-month period I was in my office 'till midnight on many days and lost at least 7 kilos, but was so happy when everything finally came together at the beginning of 2014, and I had a real book ready to finalize for publication. I really appreciated the detail and attention that came to the book because of the rigour of the Indiana University Press team, as well as the additional readings and edits provided by great colleagues such as Margaret Jolly, Carolyn Brewer and Rachel Harvey, and my husband, Nick Mortimer. So, the short answer is 15 years of research and preliminary writing, and two years of book writing!

MW: That's a pretty epic process! But wait – so Americans were the main or intended audience of your book?

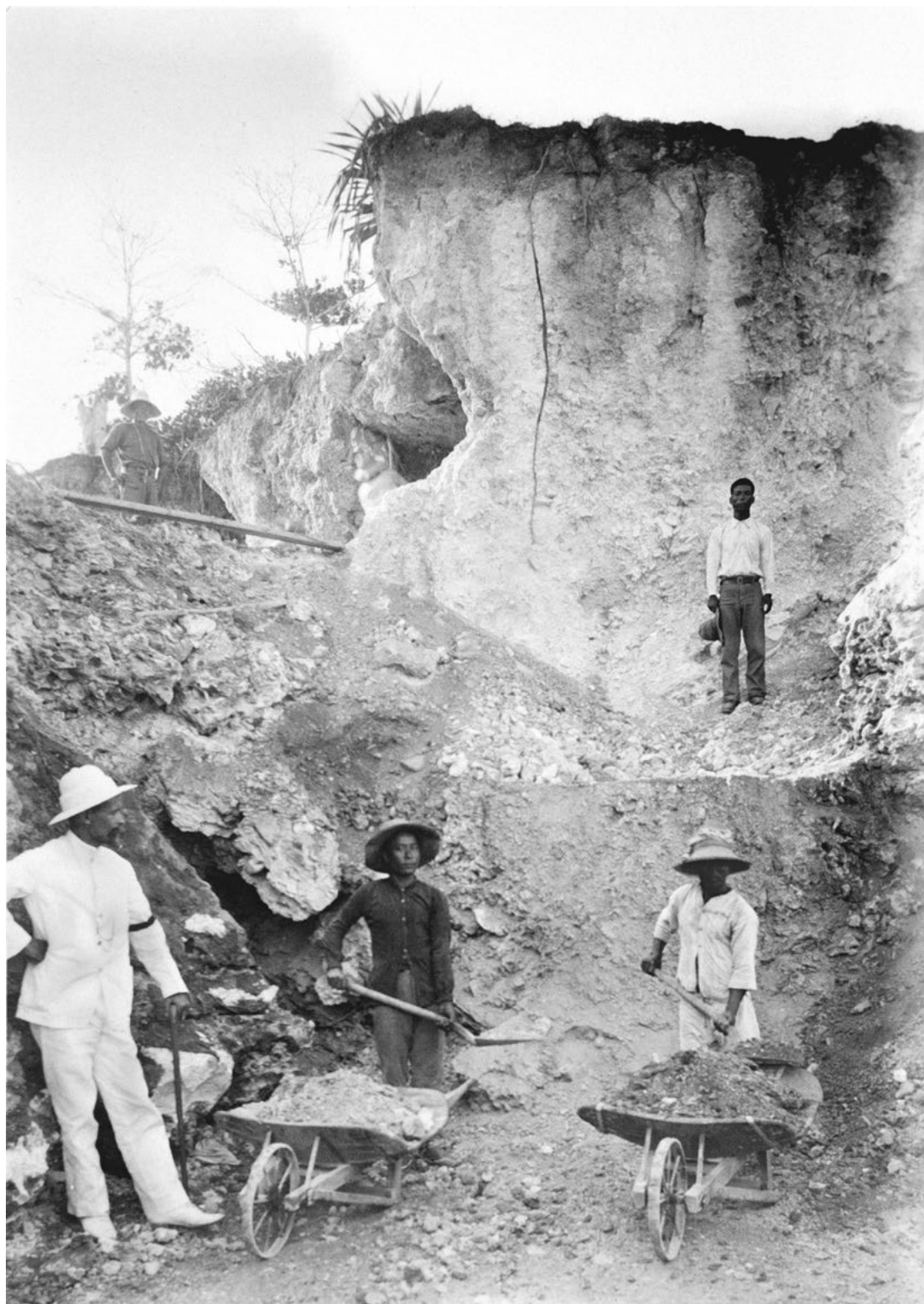
KT: I tried to write the book for anyone (or everyone) but had Banaban, I-Kiribati, Pacific Islander, Australian, New Zealand, American, and global audiences in mind, in roughly that order. I hoped people involved in environmental studies, activism, mining, resource extraction, and agricultural research or activities might also pick it up and contemplate the impact of fertilizer manufacturing and mass agriculture on indigenous peoples.

MW: What plans do you have for making sure Banabans have access to your book?

KT: I have been in conversation with Banabans who have access to the internet through a Facebook group – *Banaba: Untold Tales* – run by Kata Tawaka. It has about 300 members and I've posted all news or media and information to that page. I've also got a copy of the book for the community library on Rabi, and have given a copy of the book to the President of the Banaban group in Brisbane to share with the growing community there. I plan on sending copies to the Presidents of Kiribati and Nauru as well.

MW: Your book sits in a bibliographic genealogy that has Harry Maude's *Book of Banaba* (1994), King and Sigrah's *Te Rii ni Banaba* (2001), and Shennan and Tekenimatang's *One and a half Pacific islands: stories the Banaban people tell of themselves* (2005) as some of its predecessors. How is your book different from these? What do you think Banaban readers will make of it?

KT: Indeed, Banabans are familiar with certain versions of their history (from Maude, Grimble, Williams and Macdonald) and Jennifer Shennan, Makin Tekenimatang, Ken Sigrah, and Stacey King have produced recent books telling many Banaban and European versions of this history and contemporary Rabi life. I wrote to Ken and mentioned that I do not cover the *te aka* version of Banaban history as this is not something I know enough about. Wolfgang Kempf and Elfriede Hermann have also written many articles and book chapters about life and identity on Rabi. But I think what my book does that these works do not, is explicitly link Banaban history to that of a deep history of land, global agriculture, phosphate mining, and the significance of the phosphorus element. I thought as much about what happened to the land as to the people and previous authors have focused more on people. So I hope Banaban readers will say: "oh, that's why they wanted our phosphate so much and this is the role it played in global agriculture." And they



"Ocean Island – Very good phosphate country – No coral pinnacles in picture except the mass at back of Mr. A. F. Ellis and the corner one at right of the picture, half way up – Lower levels untouched – Ooma - September 1910." Courtesy of the National Archives of Australia

might ask: "so what is 'te aba' really, and why should we know more about the science and technical aspects of phosphate mining and environmental destruction?" I argue that what happened to the land is like what happened to the people and both are still waiting to be rehabilitated in a just fashion.

MW: Your book is part of a series called *Tracking Globalization*. Why was it important for you to tell the stories of Banaban people and phosphate in the context of globalization?

KT: Well, as a Banaban, I became very, very, very interested in what phosphate and phosphorus were and why these were such valuable elements and commodities. If we lose an island, what does everyone else gain and was it worth the sacrifice? Turns out that the globe has these planetary boundaries and phosphorus has a key role to play in the maintenance of our ecological systems. This is something I think Banabans need to know; the mining destroyed not just our island but phosphorus is a limiting factor for life on earth because it's normally locked away in inaccessible forms like rock and takes a long time to naturally cycle back through the system. So messing with natural cycles in order to mass produce food might provide short term solutions for food security but results in all kinds of other problems in terms of siphoning off key minerals strictly for human needs while destroying landscapes, oceanscapes, plant and animal life, and cultures in the process.



Banaba/Ocean Island, size of area 6.0 km²
© 2012 DigitalGlobe Google images

I used to wonder if I'd ever use my Bachelor of science degree from Santa Clara University but it sure came in handy for this research. I could generally follow the geology, biology, and chemistry I had to read to write new chapters of the book but

I was still unsure – so went to the Commonwealth Scientific and Industrial Research organization (CSIRO) in Canberra and spent a bit of time with an agricultural scientist checking things. I hope Banabans will rethink te aba, or abara (our land), in these material and global terms and realize what role our small ancestral island played not just in terms of developing Australian and New Zealand agriculture but as part of a global environmental and agricultural system. Tracking Banaban lands and peoples is a global tracking in many ways because of the chain of phosphate and superphosphate commodities, and the agricultural commodities and processes that are linked to fertilizer production and application.



Banaba pinnacles left over from heavy mining, April 2000. Photo by Katerina Teaiwa

MW: There was also another American guy who was doing a global history of phosphate, right? What was his name? Are you and he saying similar things about phosphate's role in processes of globalization?

KT: Greg Cushman wrote *Guano and the opening of the Pacific world*. I discovered it just as my book was finished and wrote to him to say: "great, I'm interested in

your work." He never received my email and I've only seen small bits of his book, but it does tell some of the Banaban story based on archives and Sigrah and King's book. I'm not sure if he travelled to Rabi and Banaba. His is very much a global history linking South America and the Pacific [update: Cushman invited me to be part of a Munich based project exploring the role of phosphorus in agricultural, environmental, historical, and cultural contexts].

But guano and phosphate are a bit different in terms of geological life, access, mining technology required for extraction, and proportions of phosphoric acid available for agricultural use, or in terms of what industries need to do, to the raw material in order to unlock the phosphoric acid (that's what you need to help improve the capacity of plant roots to take in nutrients and thrive).

Guano mining played out a bit differently in South America and Oceania but the same companies (like the Pacific Islands Company) were involved in both types of extraction and exploitation of labour and indigenous land. Guano really is piled up bird and bat poo, while phosphate is locked away in rock formation.

MW: That's interesting. You did a lot of archival research for the Ph.D. and this book, but your doctorate was awarded in anthropology. How important was anthropology for the way you've ended up writing the book?

KT: My writing is ethnographic. I tell stories, many in rich detail, so I'd say ethnography rather than anthropology *per se* was very important. However, anthropologists' previous work was very important, as was that of historians and a few scientists. So it could be described as historical ethnography but it was not written to engage or debate some particular theme, theory, or issue in the discipline.

MW: Have other disciplines influenced your analysis and writing in this book? How?

KT: History and anthropology have been the major disciplinary influences (I adore archives, they are so exciting) but interdisciplinary Pacific Studies is where my work sits, I think. And that includes the indigenous studies and cultural studies elements of Pacific Studies. Cultural Studies and Women's Studies on their own have also influenced my thinking and work, especially in terms of the politics of knowledge and cultural production.

It's not a discipline *per se* but analytically, methodologically, and politically, feminist ethnography had a major impact on my Ph.D. years, especially the writing of Kamala

Visweswaran (*Fictions of Feminist Ethnography*), Dorinne Kondo, Ruth Behar, Deborah Gordon, all the *Women Writing Culture* folks, especially Kirin Narayan. She is such a master storyteller.

Dance Studies also had a massive impact on my work, especially the work of Susan Leigh Foster, Deidre Sklar, and Sally Ann Ness. I think I write as a dancer, even when I'm not writing about dance.

MW: This is a microwoman interview, so can you tell us a bit about how women feature in your book? You've been influenced by feminist ethnography, so do you consider yourself a feminist? Can you say more about how feminism informs your work?

KT: My two academic goddesses are Kirin Narayan and Kamala Visweswaran. Yes, I'm a feminist but I find any superficial and simplistic varieties of western feminism irritating. I'm a feminist in a Catholic, indigenous, eco-critical, multi or inter-spiritual kind of way. I tell my daughter God is not gendered and definitely not a man sitting in the clouds. I believe in gender equity and equality.

Gender was not the focus of my research but I noticed it everywhere, including in the archives, and Carolyn Brewer, who worked with me on the index, found much more content than I remembered thematically on women, children, and gender issues in my book. This was especially the case with respect to land, land rights, colonialism, Christianity, spirituality, oral traditions, and resistance amongst the Banabans.

MW: Just changing tack a bit, we've been talking about academic influences a lot so far, but I wondered whether there were other less academic influences you might like to discuss. For example, have you felt our ancestors' spirits intervene or assist in the process of researching and/or writing this book at any point?

KT: Ok, I have. And it's never popular or a good move to discuss this in an academic (or public) context, unless you're talking to certain indigenous and Pacific Studies folks in Hawai'i, New Zealand, and the U.S. I have a couple of colleagues who I can talk to about such things at ANU but it's usually a no-go zone, as is revealing you have any kind of membership in organized (or disorganized) religion. Academics aren't expected to be spiritual, and definitely not religious as, scientifically, your objectivity will be seen to be compromised.

Usually I'm not sure if I'm living up to our ancestors' expectations. Right from the beginning of the research process, if not before, I had many dreams of people trying to instruct me on Banaban or Kiribati or indigenous knowledge and ways of doing or seeing things. After I went to Banaba in 1997 and 2000, I had several dreams which just consisted of skulls or heads without bodies accompanying me on the research journey and prompting me or pushing me to keep going. On Tabiteuea – our other ancestral island – I was visited by more than a few spirits and on Banaba I definitely had waking encounters with vivid things I couldn't explain but believed were messages, greetings, or acknowledgements. After Kaka (our Banaban grandfather) passed away on Rabi, I dreamt he visited our house in Tabona and spoke with our aunty as I watched from the room. And in 2011, my husband said that a tall man visited him in a dream and said to tell me I could do this book and it would be good. He said it was our American grandfather.

MW: Do you have any funny stories from doing your research or writing the book?

KT: Yes. (laughs) Many of them involve bodily functions which comes with the territory in anthropological research. One of them involves an entire section of



Ocean Island 1900, 'Native Missionary and Followers'. Courtesy of the National Archives of Australia

Betio Town in South Tarawa accompanying me to the shop to buy toilet paper and then sitting outside the school toilet, waiting, while I went. Others involve showering under the stars with some awesome nuns on Tabiteuea only to find out that a toddy cutter was up a coconut tree somewhere in the dark and decided to reveal himself by singing one of those toddy-cutting songs.

A not so funny one was when a drunk young man climbed under my mosquito net in Tekabwibwi, North Tabiteuea, while my two uncles slept not too far away, claiming he just wanted to touch my hair. I woke up while his hand was inches from my face.

Another one was when I thought I could play netball for our village, Tabiang, on Rabi but didn't quite know the rules of the game, and some clever woman put me into a match against the toughest village on the island. I think she wanted to show everyone how no amount of education will help you on the sports field. So I married a former athlete. He played volleyball for Tabiang years later and his team decimated all the reigning champions – first time Tabiang ever won a trophy, I hear!

MW: Do you feel you have exhausted the archives on Banaba? Is there more work that could be done?

KT: No, no, no. The archives of the British Phosphate Commissioners and others relevant to Banaba, phosphate and mining are MASSIVE. They're in Canberra, Melbourne, Adelaide, London, Auckland, Wellington, Suva, and would connect to other records such as cargo manifests from many more countries. And this doesn't include the content in private collections of former company employees and that of Stacey King and Ken Sighra on the Gold Coast of Australia. There is a lifetime of work to be done and I'd love to keep going. I think it would also be great for younger Banabans to study the humanities and social sciences and write more of our histories and contemporary stories.

MW: Well, that will certainly keep you busy! Thanks for taking time to share with us on the microwoman blog. Is there anything else you'd like to say to our readers before you go?

KT: *Tekeraoi* and go microwomen!



Banaba in the year 2000. Photo by Katerina Teaiwa



Reinhold Leinfelder is a geologist and a member of the Anthropocene Working Group of the International Commission on Stratigraphy. He has held professorships at various German universities and directorships at several museums and natural history collections. He is currently professor at Freie Universität Berlin and Principal Investigator at the Cluster of Excellence *Image Knowledge Gestaltung*.



Alexandra Hamann is a media designer who has directed an agency specialising in educational media and science communication since 2001. She is an editor and author of non-fiction comic books. As a freelancer working with the Cluster of Excellence, she was responsible for the storyboard, coordination and editing of *Eating Anthropocene*. She is the mind behind the idea and concept for the comic.



Jens Kirstein is a geologist and research associate at Freie Universität Berlin. He investigates relevant historical, current and future biogeological resource, energy and material flows in and around the kitchen. In addition to his work at the Cluster of Excellence *Image Knowledge Gestaltung*, he is a Ph.D. candidate of the International Max Planck Research School for Global Biogeochemical Cycles (IMPRS-gBGC).

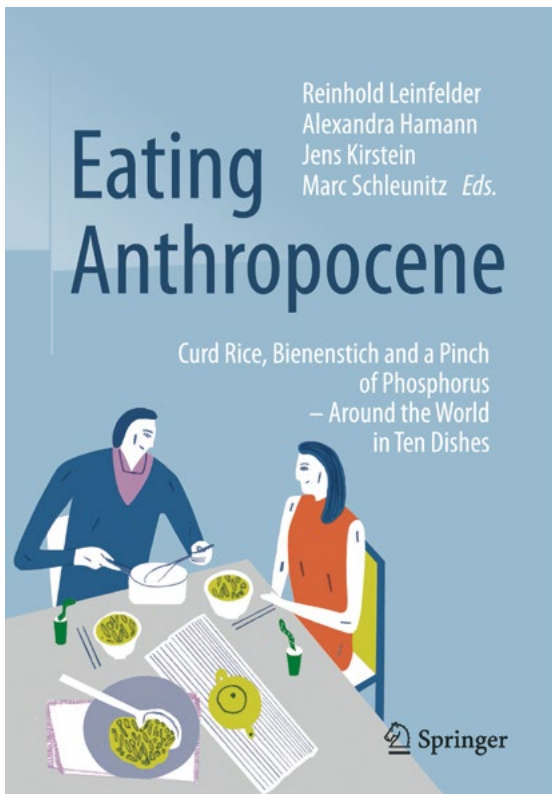


Marc Schleunitz is a biologist and political scientist. His interests lie in the correlations between humans' use and manifold transformation of the environment, their ecological consequences and their underlying economic processes. He works as a research associate for the base project with a focus on researching global nutrition and the material flows and resource usage associated with it.

R. Leinfelder, A. Hamann, J. Kirstein, M. Schleunitz

Epilogue: *Eating Anthropocene* – Merging Science and Comics

The present volume documents the twofold character of the conference *Science meets Comics* with the first part focusing on comics as a format for communicating complex topics and the second part addressing food in the age of the Anthropocene as one such example for complex topics. The overall objective of the symposium was to deal with the results and suggestions of the presentations and discussions, to find possible pathways on how to feed the world in the future and to co-produce the final chapter of the scientific comic *Eating Anthropocene* together with all artists participating in the project. In order to sum up the framing, contents and design process of the comic as well as to highlight its Anthropocene context we below provide a slightly abridged version of the preface of our comic book:¹



Eating Anthropocene

Curd Rice, Bienenstich and a Pinch of Phosphorus – Around the World in Ten Dishes

ISBN 978-3-662-50402-4, Springer-Verlag, 2016

Editors: Reinhold Leinfelder, Alexandra Hamann, Jens Kirstein, Marc Schleunitz

Illustrators: José Aguiar, Sarnath Banerjee, Zineb Benjelloun, Joëlle Ebongue, Martin Ernsten, Sophie Goldstein, Samuel Jaramillo, Sylvain Mazas, Ulrich Scheel, Maki Shimizu, Ruohan Wang, Martyna Żalalytė

Website: www.anthropocene-kitchen.com

¹ Courtesy of Springer publisher, as part of Springer Nature

Food – life-relation

Food is something that permeates all spheres of our lives. It allows us to grow from infants into adults and supplies our entire system – from our brains and muscles to all other organs and body parts – with energy and essential building blocks. The ritual of coming together to enjoy food is often the central element of our family lives and other forms of social exchange. Indeed, it's rare to have a gathering without some form of appetizer, a birthday party without a cake or something sweet, a celebration without some festive food, or a meeting with a good friend without getting a bite to eat. We integrate nutrition into our working lives, for example by meeting for business meals or networking with colleagues in the cafeteria. The way we eat is closely linked to our health and well-being. And there's good reason we say "You are what you eat". Many of us attach great importance to the layout and equipment of our kitchens, others have only a microwave. Either way, a home without a kitchen remains unthinkable.

The food production process

No matter how we consume our food, it has to come from somewhere and someone has to produce it. This has tremendous global impact, usually without any of us being aware of it. It makes a difference whether we buy our food in a supermarket or in a local store around the corner; it also makes a difference whether the goods are produced in the region or by a global corporation. Manufacturing and processing require a lot of space, massive amounts of technology, immense infrastructure and, in particular, energy. Our food also requires nutrients in order to come into being in the first place. For example, cows eat grass or increasingly soy, which in turn requires surface area, water and, once again, nutrients. These nutrients are acquired by technical means – such as the Haber-Bosch process, which generates nitrogen fertiliser, or from mined mineral resources, such as phosphate and potassium – and used on fields to increase crop yields.

Governing globalisation from the kitchen

Eating has always been and will continue to be a very local, personal and often emotional act. At the same time, when we eat, we get globalisation served pretty much directly onto our plate; we eat fruit, chocolate, spices, meat, fish, grains and vegetables, many of which have come from the other side of the world. In other words, the way we eat and prepare our food can have a significant influence on the course of globalisation. The shape and structure of the world's food supply are determined by our diet (vegan, vegetarian, etc.), nutritional style (seasonal, local, global), social housing structure (a single person has different shopping habits than a family or flat-share participants) and, last but not least, by our actual

kitchens (indeed, pots and pans need to be manufactured and transported, and gas is a different source of energy than electricity or charcoal). The food industry is an important economic factor.

Access to healthy food for a rapidly growing global population continues to be one of the biggest challenges facing the world today. It is also closely connected to topics of health, poverty, justice and peace just as much as to issues such as climate change, the protection of biodiversity and the finiteness of resources.

Nutrition as key driver to the Anthropocene

These issues land us smack dab in the middle of the Anthropocene, the epoch shaped by human beings. In order to understand what is meant by this term, we need to take a quick look back. Our species, *Homo sapiens*, has been around for roughly 200,000 years. During most of that time, we were hunters and gatherers, that is, until a little more than 10,000 years ago when we increasingly started to settle down and farm the land. We've been interfering very deeply in nature ever since. Early farmers created farmland and pastures by chopping down forests, thus plundering a natural source of carbon storage and releasing the greenhouse gas CO₂. They flooded fields to plant rice and produced yet another greenhouse gas, methane, in foul-smelling mud. By means of selective breeding and the elimination of all major enemies, human beings were able to pare down the world's natural flora and fauna. In addition to that, ever since they started exploring the entire globe in the early modern era, human beings also began taking species that appeared useful to them and transporting them this way and that, which led to a large-scale reshaping of local ecosystems.

The emancipation of human beings from the limits of their own physical strength progressed even further with the advent of industrialisation. Our ancestors had made do using only their own muscle strength. Animals, too, use muscles in their jaws, tongues and lips to pull down plants and chew, or to catch and shred prey. They dig holes, build nests and even chop down trees. The strength necessary to achieve these feats was gained quite literally from eating. This is entirely different from modern humans, who began delegating their own physical chores to animals, starting with the ox, donkey and horse, followed by water and windmills and later via steam and other types of engines. In turn, these new machines had to be fed with energy, first with wood and then with coal, gas and oil. Over the course of industrialisation, a true chain reaction of mutually reinforcing developments was inaugurated. The conversion of fossil fuels made it possible to mine even more mineral resources with which we could build more machines, which in turn required

even more energy. The result was that the machinery of production and the means of transport, including trains, cars, ships and airplanes, conquered the world.

Today, we don't have to eat more in order to move or produce things. Thanks to the energy derived from fossil fuels, all we have to do is sit at our desks and press buttons. In fact, fossil fuels represent nothing less than the preserved energy of living things, such as trees, shrubs and sea plankton, which are not eaten by other beings, but instead accumulate over the course of hundreds of millions of years as geological processes convert them to coal, oil and gas. Even resources like the majority of iron ore deposits, or the phosphate so essential to our diet, can be traced back to the natural processes of organisms.

Human beings are having such an enormous influence on the entire Earth system that geologists now describe them as representing an essential geological force in and of themselves – one that is comparable to earthquakes, volcanic eruptions and continental shifts. These are strong words, but the facts speak for themselves: today, barely one quarter of the Earth's surface that is not covered by ice remains in a state undisturbed by human beings. We have taken down mountains, created valleys, given rivers a new course, carved out lakes and let other ones dry up. We can even raise the sea level and change the climate. Each year we produce an amount of plastic equivalent to the total mass of all people alive on the planet today. Our crops and farm animals dominate the biosphere. We bundle off sediment in ways that nature could never achieve via its own erosion and transport processes. We've even created new fossils! Geologists call them technofossils: plastic particles found today at the bottom of high-mountain lakes as well as in deep-sea sediments. In fact, elementary aluminium, concrete fragments and ash particles from industrial combustion processes are detectable in deposits all over the world. Radioactive fallout from post-war atomic bomb tests, as well as from Chernobyl and Fukushima, also defines our "man-made new", which is the literal translation of the word Anthropocene. The post-glacial age of the last 12,000 years, the environmentally stable Holocene, is visibly at an end – and is being replaced by the Anthropocene.

Shaping the future

How will things continue in this Anthropocene era? Doesn't the terrifying realisation that human beings are capable of redesigning the Earth to such an extent also give us some idea as to possible solutions to the problem? In an era in which not only the destruction of the environment has increased exponentially, but also our knowledge about the underlying processes that are causing it, shouldn't we humans be capable of shaping the Anthropocene in a knowledge-based manner – like

careful gardeners – so that the planetary boundaries of the Earth system are not endangered? Perhaps we could see ourselves as part of an overall system we need to preserve? There's a reason why the metaphor of the gardener is so appropriate in this case; indeed, gardeners who want to continue to harvest crops know they must maintain their soil without overusing it. In a similar vein, those who want to live on this Earth over the long term cannot continue to exploit it. We must instead shape it in such a way that human behaviour does not destroy our own home.

But how should we behave? Or, with regard to our topic, how should we eat? How can we consume food without losing our joy of eating while also keeping ourselves and the Earth healthy? From a global perspective, we continue to have a highly varied culture of food and eating. Perhaps the solution lies in this diversity. In order to find good ideas, we have to look very closely at the world around us. Indeed, *Eating Anthropocene* is an attempt to create a cartography of eating habits on a global scale – based on examples taken from different countries and in a manner that is as open as possible. Most importantly, this approach is based on real human beings. Knowledge-based gardening needs to take into account more than just scientific evidence. Science is an important factor, but it's not enough. We need to collect experiences, regardless of whether they come from centuries-old traditions, new food fashions or the need to combat famine.

Dialogue and diversity

So we asked ten individuals from ten countries on five continents to tell us what and how they eat, but also where they shop, whether they know where their food comes from and what role the kitchen plays in the whole thing. They told us their favourite recipes, which served as anchor points for the discussions and are now contained in the comic book for you to try out on your own. The results of this process served as the starting point for our scientific research. Over the course of our constant exchange, charming stories began to crystallise little by little, and we invite you to experience these adventures, in which each chapter features one of our discussion partners in the lead role.

One element – and in this case it really is an element – that connects one chapter to the next is phosphorus. Phosphorus compounds are not only essential for all life on the planet, they also constitute – in the form of phosphate – one of the three main ingredients in all fertilisers. Phosphate increases global agricultural yields many times over and has enabled the feeding of a rapidly growing world population. Its meaning as a finite and non-renewable resource is something many people are unaware of. We would like to change that state of affairs, which is why

phosphorus and its many facets represent the thread running through all of the journeys undertaken in *Eating Anthropocene*.

Upon reading, you will also encounter yet another entirely different type of diversity. Indeed, your eyes will be the first to notice that the visual representation of the stories is marked by tremendous variety. Who better to depict the lifestyles, environments, eating habits and everyday lives of our protagonists than illustrators from the regions in which the stories take place? Twelve artists took on the challenge of this exciting project and faced the task of translating scientific facts and individual experiences into image-based stories. Each one of the completely different styles and perspectives enriches the book and reflects the cultural diversity of our protagonists. In turn, we would argue that it also reflects the diversity of the entire world.

Greetings from the future

After the artists completed their individual chapters, we brought them all together in a workshop for the purpose of creating the last chapter on the future of food. After discussing the future of the world's food supply with international experts from the symposium documented in this volume, the artists came up with a unique way to reflect the prognoses of their deliberations: they decided to take the protagonists of each chapter on a journey into the future, and to a different country. From that vantage point, each protagonist sends a postcard in which they report about life and nutrition in the year 2050. Perhaps those postcards – and the comic in general – will provide you with some ideas as to how you yourself would like to shape the future. In addition to the delicious recipes found in *Eating Anthropocene* we hope we also give you, together with this present volume, some food for thought, and for fruitful discussion.

The knowledge comic *Eating Anthropocene* is the result of a global experiment involving many participants and conducted in a manner that uses the world as a laboratory. One could also say that the mother of all laboratories is the kitchen, and our eating habits in the Anthropocene is the outcome of the experiments performed there. Perhaps the best way to show our love for our planet is through our stomachs.



There are no simple solutions in the Anthropocene epoch. Every single person lives in a highly complex system and is connected to it by his or her actions. By focusing on the example of alimentation, this interconnectedness can be exposed and presented in a form that everyone can understand. Comics as a communication medium not only have the potential to make complex issues accessible in an appealing form; the comic-making process itself can inspire scientific work, and reveal new connections.

This proceedings volume includes contributions on alimentation and comic theory by Jaqueline Berndt, Anne-Kathrin Kuhlemann, Toni Meier, Veronika Mischitz, Stephan Packard, Lukas Plank, Nick Sousanis, Katerina Teaiwa and Arnold van Huis. It is the result of the two-day symposium *Science meets Comics*, held in October 2015 in the Cluster of Excellence *Image Knowledge Gestaltung. An Interdisciplinary Laboratory* at the Humboldt-Universität zu Berlin, which discussed and developed these new means of communication in relation to alimentation.