by Gemma Venhuizen

CoCoA: The future ingredient for geoscientific research

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Even the best bakers update their recipes every now and then, to improve their world-famous chocolate pies. Why then should we not do the same within the geosciences? To keep our future research as tasty and inspiring as ever, we could start by adding some CoCoA: Cooperation, Communication and Adjustment.

Concerning cooperation, it is important for scientists from different disciplines and countries to work together and in this essay, I come up with some examples of good cooperation which could serve as possible solutions.

As for communication, I argue that scientists should focus on lay-people more often by means of disseminating their knowledge. This could be done in four different ways: through Public Awareness of Science, through Public Understanding of Science, through Public Engagement with Science and through Public Participation in Science.

Regarding adjustment, I emphasize the importance of looking at our research topics from different viewpoints – at macroscopic and a microscopic level, through the eyes of our fellow scientists and through the eyes of the lay-public.

In my opinion, interdisciplinarity and cooperation should become keywords in the scientific world and by means of this essay, I hope to stimulate the dialogue between scientists and society.

Picture a big, homemade chocolate cake. Your sister is coming to visit you with her husband and their two kids, and you want to surprise them by baking the cake. You've spent hours finding the right ingredients and mixing them in the appropriate amounts and the result is fantastic. It has a nice and spongy cake-layer as a base and on top of it, there is the most delicious cream layer, which is in its turn covered by a dark chocolate mousse. As a topping, you've arranged some walnuts in a nice pattern.

'I don't like cake!', exclaims your nephew as soon as he walks in, and he picks all the walnuts out of the cake, ruining its appearance by making large holes in the upper layer. 'You know I'm a chocolate addict', sighs your sister, and starts heaving large lumps of the chocolate layer towards her mouth. Immediately, your niece devours the cream layer, leaving only the spongy cake base for your brother-

in-law. 'Nice cake', he says. 'A bit plain, maybe, but nice.' Disillusioned, you eat the last few crumbs from the plate – if only they would have tasted the cake as a whole, they would have enjoyed it even more...

Now picture yourself a slightly different cake. The walnuts are replaced by buildings, the chocolate turns out to be a dense vegetation layer. The cream is represented by groundwater and the base layer is not that spongy anymore, as it consists of hard rock. In other words: welcome to the Earth.

And on this heavily inhabited cake, it's easy to recognize your family members. Your nephew turns out to be a promising civil engineer, your sister is a keen biologist, your niece is studying hydrology and your brother-in-law specializes in geology. All four of them are working with the earth, but they are each so focused on their own job that they're not aware of what is going on in other parts of the world – and that's a pity.

Although science is not just a piece of cake, this example illustrates the way in which many scientists work. They occupy their own niche, concentrating on their specific research area. Of course, only by doing thorough, in-depth research on a specific topic, is it really possible to unravel complex processes. On the other hand, this high-resolution, small-scale type of research cannot stand on its own. A broader, panoramic view of the scientific field is necessary to understand how all the parts of a system are related.

The geological sciences cover an area in which many different disciplines come together. A lot of cooperation is already going on in the field, but in my opinion, this interdisciplinary approach could be stretched even further. Therefore, I will try to come up with a recipe for future earth scientific research in this paper.

And to be able to do that, I will focus on the most important ingredient: CoCoA – Cooperation, Communication and Adjustment.

Cooperation – or 'four different ways to look at a pingo'

Everyone who has ever done any gardening is aware of the fact that soil isn't just some collection of sand grains – it is the whole of roots, groundwater, animal life and abiotic particles – an ecosystem that could not exist if some of the most important members were missing, because they all depend on each other. Without the water the roots would die, without the roots the soil particles would erode, without the soil the animals would be homeless.

Even on a scale of a few centimeters, it is already visible how intertwined different parts of nature are: geology, biology and hydrology all come together.

Why then, is it that these disciplines are seen so often as separate sciences?

In May 2010, I was selected to participate in a summer school on permafrost, organized by the University of Alaska in Fairbanks (www.iarc.uaf.edu/education_outreach/summer/2010). The special thing about this course was that it was not only developed not only for earth scientists, but for young scientists from different disciplines: ecology, geomorphology, hydrology, archaeology, meteorology, civil engineering and science communication. Part of the course was a field trip along the Dalton Highway, one of the world's most northernmost highways. Along the road, we saw a few beautiful examples of one of my favorite phenomena within the earth sciences: pingos. With my background in Quaternary geology, I immediately started explaining the development of these pingos (which do in fact form by a subsurface ice lens pushing the soil upwards until a hill develops).

As it turned out, I was not the only one fascinated by pingos. The ecologist pointed out to me that the small secondary mounds we saw on top of these pingos were in fact the result of bird droppings: birds rested on top of the hill (as a look-out) and their droppings provide a nutrient-rich base for the vegetation. The archeologist, overhearing our conversation, told us that human artifacts (like arrow heads) can be found around pingos quite often, because prehistoric men used them as look-outs. And the hydrologist started to explain something about the drainage patterns in the area around the pingo. As a result, each of us got wiser on the pingo-topic, just by looking at the hill from a completely different point of view.

In my opinion, geoscientists should and could use this interdisciplinary approach more often in the future. Like the IUGS already shows us, it is valuable to create a platform where different disciplines within the geosciences can meet. Or, as it says on the website: 'The Union aims to promote development of the Earth sciences through the support of broad-based scientific studies relevant to the entire Earth system; to apply the results of these and other studies to preserving Earth's natural environment, using all natural resources wisely and improving the prosperity of nations and the quality of human life' (www.iugs.org).

When it comes to academic research, geologists could look more often beyond the frontiers of their own research area. This interdisciplinary approach calls for a broader view. Courses, conferences and excursions should not only focus on rocks and faults, but also on the animals and plants that use them as their habitat; on the people that are threatened by geohazards; even on the shapes of the clouds that form above a mountain range.

Interdisciplinarity encompasses both cooperation within the exact sciences and cooperation between exact and social sciences. Particularly the second type of cooperation deserves more attention. Sure enough, most universities incorporate courses like history of science and philosophy of science in their colloquium, but most students regard them as a necessary evil. Why not incorporate a little bit of history and philosophy in each geology-related course, instead of making separate courses out of them? In that way, students will get used to these subjects, instead of regarding them as the 'odd-ones-out'. In addition to history and philosophy, other disciplines could be combined with the earth sciences as well: economics (focusing on the exploration of minerals), archeology (focusing on the relationship between geomorphology and the distribution of old settlements, or between petrology and tool making) and maybe even literature (focusing on how landscapes are depicted in novels). Such programs could make young scientists aware of the fact that the

spectrum of science is broader than just the part they're studying themselves.

A good example of improving cooperation between sciences was the conference of the International Polar Year held in Oslo in the summer of 2010 (www.ipy-osc.no). The great thing about this conference was that it wasn't only about geoscience, but also about biology, management, communication, politics – everything associated with the poles. In my opinion, it would be a good thing if magazines, courses and conferences would have a system-based approach in the future (i.e., focusing on a specific area or ecosystem for example). Another interesting example is the existence of Scientific Journal Publications (www.science-journals.org) and Scientific Journals International (www.scientificjournals.org/index.php). On these websites, a whole range of scientific papers is available for free – right now, the field encompasses physical science, medicine and health science, biology and social science. The physics section already contains a few geological journals (a.o. the *Journal of Geology and Mining Research*) and it would be wonderful if more geoscientific journals would become available for free on this website, to make it easier for scientists from other disciplines (and for journalists, as a matter of fact) to read something about a topic they are not too familiar with.

Cooperation does not necessarily have to be linked to inter-disciplinarity between sciences – there could also be more cooperation between different countries. Once again, the IUGS sets an example by creating a platform for 121 nations. In many field projects, there is a quite good cooperation between different countries already and more than 5000 geoscientists from all over the world attended the 33rd quadrennial IGC in 2008 (www.34igc.org/sponsorhip-enquiries.php). However, there are also researchers from different countries who all try to solve the same problem separately.

Luckily, a positive trend can be seen already. Especially for young geoscientists, some great international platforms exist: the YES-network (Young Earth Scientists), APECS (Association of Polar Early Career Scientists) (www.apecs.is/) and PYRN (Permafrost Young Researchers Network) (www.pyrn.ways.org/). These networks do justice to the literal meaning of the word 'network': they create links between different groups of people. By enabling webinars and by sending digital newsletters, they facilitate contact and knowledge exchange between scientists of different countries in a quick, easy and low-cost manner. Moreover, these networks organize meetings, both for members from developed and developing countries. For example, the YES is organizing a big YES Africa conference in 2011, thus enabling contact between African geoscientists and geoscientists from other parts of the world (www.networkyes.org/index.php/meetings/yes_africa_2011).

Last but not least, it would be desirable if scientists could cooperate more with nature itself. Over the last few centuries, we made ourselves part of the landscape. Our highways meander like rivers, our industrial installations look like modern volcanoes, pumping smog into the air. Our buildings may be the walnuts on the cake, but our influence stretches further than that. In a way, we are the ones baking the cake and that makes us responsible for the end product.

During the next few decades, our presence will be felt even more, as the number of people inhabiting the planet is increasing. Therefore, the future of geoscience should also be about responsibility, about how we can take care of the earth – to make sure there will be enough cake left for future generations. And closely related to this topic, there is another important keyword: communication.

Communication – or: how to come out of our ivory towers

Remember that piece of garden soil, in which the roots, the particles and the animals all need each other? The same goes for society. Even though we live in an age of ongoing individualism, with the pre-fix ‘i’ popping up in front of phones, books and pads, we cannot function without each other. We need – among others – bakers, nurses, plumbers, teachers, policemen and scientists to make the human ecosystem work. Most of these groups occupy a clearly structured niche, in the centre of the ecosystem: they bake bread for anyone who is hungry, they take care of anyone who is ill, they fix the plumbing for anyone whose sink is broken and they teach anyone who is interested. The scientists, however, seem to occupy a niche somewhere on the border of the ecosystem – each discipline dwelling in its own ivory tower, in order to avoid distraction by colleagues from other research areas or by society as a whole.

However, we forgot to make an entrance door in these ivory towers. We only have a small window, very high up, through which we watch society every now and then. We have locked ourselves up, waiting for the knights in shining armor that are called ‘journalists’ to climb our long, golden hair and hear all about our fascinating research. But unfortunately, science communication is not a fairytale. If we want to make ourselves heard, we have to throw our own rope ladder out of the window and meet up with society in the city center. We have to communicate what we are doing, to transfer our knowledge to the lay-public, instead of performing ‘iScience’ by only minding our own business.

In my opinion, an appropriate way of doing this would be by means of the ‘PAS PUS PES PPS’ model (Van der Sanden and Meijman, 2008). According to this model, there are four ways of disseminating scientific knowledge to a lay audience: by means of Public Awareness of Science (PAS), Public Understanding of Science (PUS), Public Engagement with Science (PES) and Public Participation in Science.

The first element of the model, PAS, simply is about making people aware of the existence and basic meaning of the geosciences. That sounds straightforward, but in reality, that is not always easy. Particularly in a flat country like the Netherlands, where no mountains or volcanoes can be seen, many people are quite ignorant when it comes to the geosciences. Quite often, they think that geology is the same as archeology, and I have to explain over and over again that I’m not looking for old bones but for old stones. And when I first went to college, my hearing-impaired grandfather mistook ‘geology’ for ‘theology’ and asked me all about the Bible.

On the website of the IUGS, it says that one of the goals is ‘to strengthen public awareness of geology and advance geological education in the widest sense’ (www.iugs.org).

Introducing people to the geosciences could be accomplished in a number of ways, for example by putting signs with geologic background information at sightseeing spots – just to make them aware of the fact that they’re looking at a geologic phenomenon.

Often there is a thin line between PAS and the next element: PUS. Public Understanding of Science is about increasing general geologic knowledge, and this can be done in various ways: by publishing popular-scientific books and articles on earth science and by creating exhibitions around geological topics, for example. Often, people think about PUS when they think about science communication and knowledge transfer is very important indeed. The important thing is

to find the right way to transmit the knowledge, because hard-core science is not that attractive to lay-people. Even for geologists it is not always tempting to wrestle through scientific literature, as it is often written in passive, objective language. ‘Hell is sitting on a hot stone reading your own scientific publications’, as Kaj Sand-Jensen put it in his article *How to write consistently boring scientific literature* (Sand-Jensen, 2008).

It has not always been like that. A few centuries ago, many scholars were skilled novelists or poets at the same time. Beatrix Potter, author of the famous Peter Rabbit-series, was well known for her studies of fungi; the notebooks of the Swedish botanist Carl von Linné contained both scientific observations and exciting travel descriptions; Charles Lyell’s *Principles of Geology* were not only famous among other scientists (like Charles Darwin), but also among lay-people – in the introduction to the *Principles*, it is said that ‘in prison for blasphemy in 1842, the atheist agitator Charles Southwell asked for a copy along with his accordion and some cigars.’ (Secord, 1997)

Why not stretch the strict boundaries of scientific writing a little bit? Why not adopt a lighter, slightly more personal tone in our articles every now and then, just to make them more readable? Why not organize some journalistic writing courses for scientists? Or some geology courses for journalists? The Geological Association of Canada (www.gac.ca/awards/Fortier_journalism_award.php) and the Earth Journalism Network (www.awards.earthjournalism.org/about-competition) already set a good example by handing out awards for earth science journalism and the National Center for Atmospheric Research has organized a Journalism Fellowship to introduce journalists to the earth sciences for three times in a row (www.ncar.ucar.edu/resrel/jfellowship/). At the Columbia University in New York, it is even possible to take a course in earth science journalism. It would be wonderful if more of such courses would exist, but unfortunately, the opposite seems to become true: the Columbia University has announced that it will not accept new students for the fall of 2011, due to the current weakness in the job market for environmental journalists (www.ldeo.columbia.edu/edu/eesj/).

Therefore, it might be a good idea to try and reach the public in other ways as well. Public Engagement with Science (PES) is about the emotions which can be invoked by science – and it is closely related to the beauty behind science.

For example, the geological novels that have been written over the last centuries (not least Jules Verne’s *Journey to the center of the earth*, about a descent into an Icelandic volcano; Verne, 1864) have served the goal of PES. Verne might not have contributed to Public Understanding of Science, by his far-fetched theories about volcanoes, but at least he managed to stimulate the scientific fascination of his readers.

Of course, engagement with science can be stimulated in more ways than just by means of literature. In February 2011, an exhibition entitled *Beauty in Science* was opened in the Netherlands, showing pictures from ten scientific disciplines (among which geology) (www.boijmans.nl/en/7/kalender/calendaritem/754/schoonheid-in-de-wetenschap). No signs were present to explain the phenomena visible in the pictures – visitors were left alone with their imagination. And the reactions were overwhelmingly positive.

Last but not least, science communication can take place via Public Participation in Science. By actively taking part in geology (for example by going on a guided excursion), people can experience the landscape. The American Marine Biological Laboratory and the

University of Vermont even organize an annual Polar Hands-On Lab, in which journalists can participate in a scientific research project and afterwards write an article about it (www.mbl.edu/sjp/environmental.html).

All these four strategies (subsequently increasing the awareness, the knowledge, the engagement and the participation of the public) are in my opinion valuable and it would be worthwhile to focus on ways how to enhance them in the future.

As an example, we can look back at the International Year of Planet Earth (2007-2009), during which all kinds of activities took place (www.yearofplanetearth.org). The organization of such an event was a perfect example of PAS, the lectures that were given supported the PUS-part, the beautiful exhibitions around the world increased the PES and the many excursions took care of the PPS. What was more, the International Year of Planet Earth was a great example in which cooperation and communication came together: scientists, journalists and lay-people around the world were experiencing the Earth and felt the need to take care of it.

Adjustment – or: ‘Replacing iScience by eyeScience’

More than 400 years ago, two inventions were made that led to great scientific breakthroughs: the microscope and the telescope. The first has become an indispensable tool for biologists, geologists and health scientists alike; the second has been essential in our discovery of the space surrounding our earth.

And together, these two inventions represent the third important factor of CoCoA: adjustment. They make it possible to change our viewpoints, to zoom-in and zoom-out, to make the unseen things visible. Only by looking at things from different angles, is it possible to get a clear picture. Depending on the scale and the viewpoint, different phenomena emerge: some major faults can only be seen from the air, while small frost cracks in a pebble are barely visible with the naked eye.

In my opinion, this ability to adjust is crucial in science – not only in a literal, but also in a metaphorical sense. It is all about scope – it is not the ‘iScience’, but the ‘eyeScience’ that matters. We should

look more often through the eyes of fellow scientists and of lay-people to analyze our own research. In that way, we can stimulate our ‘out-of-the-box thinking’ and come to new insights.

In my opinion, all different levels of scientific research are important. I don’t adopt the reductionist point of view, which assumes that all science could be reduced to ‘fundamental’ science (i.e., physics). On the contrary, I think that new insights emerge if you add different sciences. You cannot predict how a river will run by staring at the individual water drops; you cannot know what a cake tastes like if you only try the separate ingredients.

We should break down the ivory towers belonging to the separate sciences, but not leave the building blocks unused. From the debris, a center can emerge – a research center where scientists from different disciplines work together; a visitor center where citizens would not have to pay an entrance fee and where they can communicate with scientists. Where they can experience, learn, admire and take part in science.

The future of geoscience is about developing a unifying language; by providing a recipe to make our planet the most delicious chocolate cake ever. All the layers are tasty, but they taste the best as a whole. Only together can we bake the most delicious cake.

Tuck in!

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