Transformation science: seven collective questions for a just and sustainable future[1]

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In times of change, the model of science as solely an objective reductionist approach to inquiry is changing too. In cases of development, whether the changes are primarily social or primarily environmental, scientific inquiry needs to capture the full scope of the interaction between the two. This paper offers a framework for inquiry that draws on the full range of human experience, all of which needs to be considered under conditions of development and transformational change. Personal, biophysical, social, ethical, aesthetic, and sympathetic questions need to be asked of any significant issue, followed by reflective questions on the meaning of the combined answers. The collective answers that come from all the diverse interests in a development programme, from crossing the boundaries between key individuals, the local community, expert advisors, organizations and creative thinkers provide a collective understanding of the needs of a just and sustainable future for the whole development community. Collective action research based on collective learning was the research method employed by the Local Sustainability Project 1992-2013 in communities coping with transformational change. To illustrate transformation science, the approach is applied to sustainable development of the Mer culture from the Murray Islands of the Torres Straits Islands, previously part of Australia.

Context: understanding the whole

It is new to the practice of science to be asked to study the whole of an issue in its social context and to deliver solutions at both the planetary and the local scales. Yet this is being asked of scientific inquiry in this era of transformational change (Ravetz 2005). Traditional science reduces complexity, relies on objective observations, and trains its apprentices in the same mode (Toulmin 1972). Scientific inquiry is used to abstracting the particular segment of reality that fits in the scientists' discipline and studying it within the framework of that discipline (Chalmers 1994).This reduces the complexity of the issue and makes it easier to find a part-solution. This approach also reduces the opportunity to find a comprehensive solution. Furthermore, it separates the issue from its context and so from effective action.

Science is now being asked to provide advice on how to deal with the unprecedented and interconnected events that are leading to the present era of transformational change (Brown, Harris and Russell 2010). Since the events are to a great extent human-generated it is not possible to treat them solely objectively or to continue with methods of inquiry suited to technological solutions. Since the changes are due to the activities of the human species, our era has been labelled the Anthropocene (Crutzen and Stoermer, 2000). After the Stone Age, the Bronze Age and the scientific age, the world has arrived at the human-dominated age without the tools to understand the changes. Philosopher Thomas Berry has called this a moment of grace, a space in which we can learn ways to move towards a humane and sustainable future (Berry 1999).

Localities all over the planet are being exposed to global industrial pollutants, often ones whose local effects are unknown, such as the persistent organic pollutants which are by-products of chemical production (Jones and de Voogt 1999). Many local communities are newly exposed to infectious diseases as the climate changes and global travel increases; and to the rapid escalation of lifestyle diseases as dietary habits and environments change. Planning regimes in both developed and developing countries are already taking account of the storm surge and floods exacerbated by climate change, the increasing urban density from the move to the cities; and the need for social housing for the disadvantaged from economic crises.

Under these conditions a transformation science is needed that is able to tackle the whole of complex issues; embrace change and uncertainty; and take full account of both the local and the global context of an issue. Taken together, these changes add up to a new approach to science. Science itself has changed over the past half-century, exploring systems thinking and linking qualitative with quantitative evidence (Ravetz 2005). However, science as currently practiced does not readily link itself with other ways of knowing. A transformation science, on the other hand, will not only claim the right to use any combination of disciplines. More than that, it will need to access any way of knowing that will increase the understanding of the issues and their possible resolution (Brown *et al.* 2010).

The pressure towards a new and inclusive type of science is not new. In the early 1970s planners, Rittel and Webber (1973) wrote a paper that faced squarely up to the complexity of the issues being faced by development: the multiple interests, the local and global environmental changes, the cultural shifts and the unknown future. Decision-makers were asked to tackle the whole of complex problems, embrace change and uncertainty, and take account of the full context of an issue. Rittel and Webber called these complex issues 'wicked problems' because they are an integral part of the society that has generated them, and so therefore cannot be resolved by doing business as usual. A wicked problem can never be resolved by any one interest, given the many interests involved. There can be no final solution, since any resolution will undoubtedly generate further issues. Since the context is continually changing, solutions cannot be true-or-false or good-or-bad but are only the best for that time. Such problems are not morally wicked, but diabolical in that they resist all the usual attempts to resolve them.

Silvio Funtowicz and Jerome Ravetz (1992) developed a science to operate under the pressure of wicked problems, when, as they say, facts are uncertain, values in dispute, stakes high, and decisions urgent. These are also the typical conditions accompanying transformational change. These authors called their new science Post-Normal Science to mark that it went beyond Thomas Kuhn's work on the mechanical and repetitive nature of normal science, and embraced the imaginative, creative and rule-breaking nature of revolutionary science (Kuhn 1962). Post-Normal Science differs radically from traditional science in that, instead of simplifying, it embraces complexity by examining all the contributing factors with the aim of capturing the essence of an issue. This will require including all the interests in any development issue, the marginalised and vulnerable as well the powerful, the old and the young, and the developed as well as developing countries.

Issue: fragmentation and conflict

The set of interests that make up the decision-makers that shape the future of a community are the key individuals, the affected community, the relevant specialists, the influential organisations and the innovative thinkers of the locality (Brown 2008). Each of these will have different interests in the response to and the outcome of social and environmental change. Each interest will be asking different questions about the changes, drawing on different sources of evidence and perceiving a different version of events. It can be argued that each of these interests acts as a different culture with a different interpretation of reality (Brown *et al.* 2010).

In order to establish the whole pattern of transformational change in which the chosen issue is embedded, the challenge is to draw on the contributions of all the interests and to bring together all the evidence. This approach to inquiry is in marked contrast to the reduction to single factors and the use of specialised objective measures of traditional science. This broader, more open approach necessarily involves the interests learning from each other and so scientific inquiry becomes collective learning. When the inquiry includes research partners who collaborate both on the investigation and in applying the findings to local conditions, then the inquiry becomes collective action research.

Resolution: collective thinking in a transformation science

Collective action research based on collective learning was the research method employed by the Local Sustainability Project 1992-2013, in communities coping with transformational change across Australia and in Fiji, Malaysia, Hong Kong and Nepal. The aims of the Project were initiated by the first United Nations Conference on Environment and Development in Rio de Janeiro in 1992. The only direct action program endorsed by that historic meeting was Local Agenda 21. Local Agenda 21 was a program signed off by all members of the United Nations. The aims of Local Agenda 21 were also the aims of the Local Sustainability Project:

shared governance for a given locality which incorporates the goals of all stakeholders in that community, and balances social, economic and environmental resources (Local Agenda 21, Chapter 28).

Over two decades from 1992 – 2002 the Local Sustainability Project developed a research framework and set of research questions from over 300 collaborative research projects seeking local transformational change. In order to make collective decisions, the participants of the projects were required to respect the diverse evidence bases by which each interest group made their decisions. Observations from the projects and everyday common sense found that, while interest groups each built their own version of reality through using one preferred evidence source (Brown 2008) individuals across all the groups made use of seven avenues for collecting evidence every time they make a significant decision.

No matter what the preferred evidence base of their interest group, all participants drew on their assumptions about the issues (personal questions), made observations of the physical situation (biophysical questions), considered the social consequences of the changes(social questions), drew on an ethical basis for making their decision (ethical questions), felt the aesthetic sensation of something 'feeling right' (aesthetic questions) and experienced the sympathetic influence that comes from their companions (sympathetic questions). In order to make a final decision they drew on the answers to all these questions, often implicitly and without realizing that they had done so. The final reflective decision(s) might be in the flash of an eye or it might take months of reflection and discussion. However, it always absorbed information from all seven ways of thinking (Table 1) (Brown and Harris 2014).

Table 1: Collective sources of evidence for transformation science

Type of question	Sources of answers
Outward-looking questions:-	
Biophysical: what is?	Observations, measurements and descriptions
Social: who are we?	Narratives, norms, rules, myths and symbols
Ethical: what should be?	Ideals, principles, aims, standards of good and evil
Aesthetic: what feels right?	Designs, visions, standards of beauty and ugliness
Sympathetic: I and thou?	Feelings, relationships, trust, sense of the other
Inward-looking questions:-	
Personal: who am I?	Introspection, autobiography, identity
Reflexive: what does it all mean?	Cultural frameworks, pattern languages, systems

Even with the best of intentions of drawing on all the evidence, the Western cultural tradition privileges the biophysical and the social sources of information (Brown 2008). It is rarely explicit about drawing on the ethical, aesthetic and sympathetic, with the outcome that the physical and the social may be the only sources reflected upon in even the most important decision. In the transformation science proposed here, however, the concluding reflection will need to include the answers to all seven questions. The answers will each need to be explicitly subjected to their own appropriate tests for validity and truth.

Table 2: An example of transformation science inquiry: the island of Mer

Type of question	Sources of answers
Outward-looking questions:-	
Biophysical: what is?	Population 450, of Pacific origin, on an island threatened by sea-level rise
Social: who are we?	Meriam people, independent warriors with a sea-faring history
Ethical: what should be?	Standards set by *Kustom*, influenced by head hunting traditions, the Christian Bible, and modern education
Aesthetic: what feels right?	Drumming, dancing, carving, headdress and masks, singing carry cultural stories
Sympathetic: I and thou?	Strong sense of belonging to the island and the cultural traditions
Inward-looking questions	
Personal: who am I?	Warrior, protector of my country, loyal to chief
Reflexive: what does it all mean?	Cultural frameworks, pattern languages, systems

Transformation science may still choose to maintain its expertise in exploring the observable, material dimension of the selected issue, an expertise that can contribute to the observable evidence of the other questions. On the other hand, transformation science may recruit individuals or groups of individuals with expertise in each of the other forms of evidence: introspective, ethical, aesthetic, sympathetic, and reflective. Having identified the responses to

the other questions, needs to ask the concluding reflective question: 'Taking all the answers together, what is the significance of it all?', 'What does it all mean?' Or even 'So what?"

A far-flung group of islands, Murray Island, one of the Murray Group in the Torres Strait Islands situated in the Pacific Ocean to the north of Australia, provides an example of how transformation science might work in practice (Figure 1). Each source of evidence is equally important, not dominated by the quantitative or the qualitative, but taking account of all avenues of experience. Each contributor already has a cohesive understanding of their own personal and social position and the physical, ethical, aesthetic and sympathetic traditions that underlie the transformational changes to their Island. Having agreed that the basic set of interests in any locality will be key individuals, affected communities, relevant experts, influential organisations, and imaginative thinkers, each of the interest groups will be encouraged to ask their own leading questions. All of these interests will ask all seven questions (Table 1) as follows:

Personal questions
Everyone involved, from all of the interest groups, has some established ideas on who they are. As an adult, their identity and personal knowledge has already been established (Polanyi 1958). They will already have a personal method of inquiry, a framework for understanding through which they perceive the issues arising from the change. Therefore a collective action inquiry begins with the question 'Who am I? What am I contributing to this enterprise?' Each member of the inquiry asks themselves: 'Am I villager, an elder, a funding source, an administrator, a community worker, an anthropologist, a scientist?'

For the Murray Islands, the groups involved in decision-making on island matters include office-bearers in the Local Government Council; respected elders; male and female, old and young; full-time residents of the islands; expatriates who visit occasionally; environmental health, community health, education, police, water and electricity services; members of Federal and State authorities; and the carriers of Meriam culture through carving, drumming and dance. The ancestral image still held by Murray islanders is of a fierce warrior, a head hunter skilled in martial art and seamanship (Table 2).

Physical questions
Physical questions explore the material world. This is the world we can see, touch, count, measure. We invent highly creative tools to extend our own capacity to investigate and describe. Telescopes and microscopes, the computer and the abacus, the mind map and the mud map, are all extensions of the human mind as well as physical tools (Popper 2002). The design of the tools determines what you measure and the numbers you can count. Measurements and numbers by themselves without the answers to the other six questions provide no context for interpretation or decision-making

Murray Island itself is one of three volcanic islands with a local resident population of about 450 people, identified in eight ancestral tribes of Melanesian (Pacific) origin, living on Murray for many thousands of years. The Island is located in the Torres Strait, off the northern tip of

continent of Australia, a historic means of passage between the Indian and Pacific Oceans (Figure 3). It is also part of a two-way land bridge between Asia with its infectious disease profile and Australia with its Western life-style diseases.

Figure 1: Murray Island; Meriam men 1907; Edward Marbo's tombstone

The island has red fertile soil with dense vegetation in a tropical climate with a wet and dry season. The surrounding seas are rich with fish, a major component of the diet. Some of the islands are at sea level and are already among the first islands to have to be evacuated with the global rise in seal level.

After the Melanesian peoples had lived in the Murray Islands for thousands of years, The London Missionary Society spread their message throughout the Islands in 1872. The Queensland Government annexed the islands in 1879. In 1937, after long resentment at distant government, island councillors achieved the Torres Strait Islander Act establishing independent local governments on each island. During the Pacific War, the Islanders formed the Torres Strait Light Infantry Battalion to defend the straits. Post-war, Islanders migrated to mainland Australia as jobs disappeared from the pearling industry. Those remaining called for independence from Australia, claiming that the government failed to provide basic infrastructure on the island.

Social questions
Their social capacity has allowed humans to live in all the climates of the world, through social adaptations that include language and diverse systems of belief, governance, and resource management, housing and child-rearing. This is as true of the smallest village as the most powerful nation (Mills 1970). The people of Murray Island call the island Mer and themselves the Meriam people. They maintain their social traditional beliefs and actions in spite of influences from Local Government regulations, the enthusiastic adoption of the Christian religion, and the availability of consumer goods and of television. The Community Council, responsible for roads, water, housing and community events, has a major influence on community life; the elders of the community hold positions of great respect. Warfare (both inter-tribal and against European ships in transit through the Coral Sea) and the memory of head hunting remain part of the cultural history of all Torres Strait islanders.

The tradition of fierce independence continues among the Meriam diaspora, who have helped in the achievement of the Island's independent Council and the continued recognition as an independent people in all national affairs (e.g. the Australian National Aboriginal and Torres Strait Island Equity Council, Health Plan, Studies). This strong social identity has enabled major changes in Australian Federal Law and mainstream Australian attitudes, moving from treating Australia as an empty land when Europeans arrived in 1788 (*terra nullius*) to accepting that the mainland of Australia was lived in and governed by an intricate system of tribal groups for over 40,000 years. As a result of a Murray Island initiative, Australia is now subject to land claims by Aboriginal or Torres Strait Islander peoples, with successful claimants entitled to royalties for its use and a say in its governance.

Ethical questions
Ethical questions take the form of 'What should be? How should we live? How should we treat each other? What are the principles by which we should share resources, help others in need, live up to our own ideals?' All human societies construct a reference point intended to keep intact this complex network of rules for living together (Mackie 1990). All societies have customs that allocate power. All have sanctions for those who transgress ethical guidelines. Murray Island has inherited three ethical traditions, and so three sets of ethical principles, the independent warrior tradition, non-conformist Christian principles, and the Western science unbiased, objective tradition. Working with Murray Islanders, it becomes clear that all three traditions are taken seriously and provide principles for island ways of living. However, the possible conflicts between the three are bypassed by the continued referral to the ancient system of behaviour and relationships known as *Kustom*.

Aesthetic questions
Societies differ widely in their choice of aesthetic expression and response. In all cultures, aesthetic expression is a heightening of the emotions released by the patterning of ideas through sound, movement, sight, touch and language. Scientists express their sense of the aesthetic by describing their work as 'a beautiful experiment', 'an elegant solution', and 'a fantastic result'. Every local community has some shared ideas about the aesthetics of acceptable order and disorder: for example, arrangement of houses and amount of rubbish in the streets (Budd 1998).

On Mer, drumming, song, and dance in their signature headdresses remains an integral part of the language that transmits the social rules and ethical principles of island life. Festivals include uniquely Island celebrations such as Mabo Day, Coming of the Light, and Tombstone Openings (Figure 1). The tradition of a twelve month anniversary of the death of a relative is celebrated at their tombstone with dance and ritual that carries aspects of all three ethical traditions. Mer artists are recognised as outstanding in the mainstream Australian cultural community. Ricardo Idagi from Murray Island won the main prize at the Western Australian Indigenous Art Awards in 2009. Modern Mer headdresses have a special section of their own in Australia's national art gallery.

Sympathetic questions

In any community, there are many patterns of sympathetic understanding, within the young and among the old, within the long-established and among the newcomers that underpin the rhythm of the community (Buber 2000). Any account of a community needs to take account of these inter-personal relationships. While formal relationships of kinship and power are readily observed, sympathetic relationships which can actually govern the course of events are much more subtle and need to be experienced from inside the community.

The human capacity for sympathy that crosses physical and cultural boundaries lies behind the recent changes to Australian legal history instigated by a Murray Islander, Edward Mabo. A plea to the right to their ancestral land began with a passionate individual, Eddie Mabo, denied the right to return to his birthplace by the then government. Support came from the diaspora of Murray Islanders on the Australian mainland, then to a dedicated team of Australian lawyers, civil rights advocates and equity lobbyists, through the Supreme Court of the State of Queensland to the High Court of Australia. Eddie Mabo was given the rights on his land on 3 June 1992, three months after he died. This decision was based on the unbroken possession of Mabo and Passi ancestral land on one of the smaller islands. The same principal is now applied to indigenous ownership for Aboriginal people all across Australia. Eddie Mabo was buried on Murray Island with the traditional ceremony for the burial of a king.

Reflective questions

The closing reflective question in transformation science, the 'So what?' question or 'What do we do now' is a considerable challenge to current decision-making processes. The Western tradition is to expect conflicts of interests from among the interested parties. To belong to a community of scientists is to be trained never to be anthropocentric, that is, for an inquiry to be human-centred is scientifically in error. Scientists are taught to recognise logic and rational thinking alone rather than to include their insights from their imagination, creativity and intuition. Yet brilliant scientists from Einstein and Bohr to Oppenheimer have vividly described these latter contributions to their work (Oppenheimer 1955). Scientists are expected to think independently and alone, in spite of the fact that science is one of the most tightly cohesive of groups.

Murray Islanders, that is, the Meriam people, are familiar with considering issues as an interconnected whole, with well-developed skills in all seven patterns of thought. They are practical seafarers with navigational skills. Their social cohesion is strengthened by their shared image of themselves as strong and independent warriors. Their ethical principles are derived from a coherent system of Kustom stories which embrace all seven ways of knowing. Their aesthetic senses are highly developed in their dance and dress that enhance the warrior and Kustom traditions. The strength of their sympathetic loyalty to each other and their shared homeland has been thoroughly demonstrated in the Mabo decision. Each of these pathways for interpreting their world has its own interface with the each of the others, making for a coherent whole and a strong sense of identity.

The practice of transformation science

In all cultures, whether developed or developing, asking and answering reflective questions is the greatest challenge for transformation science. For the first six questions, it is becoming accepted that there will be different positions on the same issue, a change encouraged by the spread of social media. Ways of answering physical and social questions are well-developed. Answering ethical, aesthetic and sympathetic questions is less well-developed although there are familiar pathways in all communities. Considered methods of collecting diverse evidence, finding ways to bring it together and finally to convey the result to others are also needed, although only just beginning to emerge in the general practice of inquiry. Reflective questions ask for some skills often not recognised as a crucial element of science itself. Imagination, creativity, intuition are crucial uses of the human mind. Ever since the dawn of the scientific era they have been devalued by empirical scientists. Their use contrasts with the rules taught to scientists that all valid scientific evidence must be reliable, repeatable and reproducible. That is, they must be able to repeat their investigation with the same methods and get the same results, and other scientists must be able to reproduce the results for themselves.

This may work for physical experiments under conditions of control in a laboratory. The minute the inquiry goes into the field, the physical conditions cannot be held rigidly constant. Once biological systems are added, the context and the living forms initiate mutual feedback systems which have to be taken into account. Once the inquiry involves human beings, issues of choice and learning come into play (Brown and Lambert 2013).

In becoming transdisciplinary, that is, going beyond the disciplines and introducing multiple sources of evidence, there is still the issue of conveying the collective understanding to the wide range of interested parties. Each of the contributing interests is likely to rely on only one of the sources of evidence, and use only the terms associated with that source. This is demonstrated by the use of numbers that provide the language of scientists; social inquiry that uses narrative; the principles that convey answers to ethical inquiry; the artefacts that demonstrate a community's aesthetics; the emotions that reveal the sympathetic; and the introspective musings of the individual.

In summary, in a collective inquiry using transformation science, two combinations of questions need to be asked. The first five are asked by the investigator(s) exploring the chosen topic in its context. The last two are asked by the investigator(s) of their own thinking (Tables 1 and 2). For the first five external questions, much evidence will already be available. This can be collected through literature reviews, records, interviews and observations of behaviour and events. For the two internal questions, the answers lie with the understanding of each of the interested parties. Personal questions are answered by each participant in the inquiry reviewing their existing assumptions about the probable answers to the first five; they may well be surprised at each other's expectations.

Sharing the findings from answering reflective questions is a different challenge. Whatever the type of question an inquiry starts with; there will already be familiar ways of bringing the findings from the different interests together. Scientific inquiries now issue synthesis papers in addition to the usual thick research report. Social inquiries, with their multiple case studies and large and diverse study populations, are choosing to include in their final report narratives that encapsulate the more detailed findings. A narrative can be more telling, and convey the spirit of the findings more effectively than any amount of collected data. Film equipment has become technically advanced and cheaper, making it more accessible to the subjects of a study as well as the researchers. Avenues such as YouTube and Facebook allow the findings to go far and wide – going viral is the technical term.

A collage is the term for an artwork constructed of different art pieces placed together so as to convey a new idea, or a different perspective. A collage is the antithesis of a jigsaw. With a jigsaw the pieces are designed to fit together to form a copy of a predetermined picture. With a collage, the pieces remain recognisable as each carrying their own message, and a new picture is formed from their very diversity. The carriage of the reflective story or collage can be a single person answering all the questions or a transdisciplinary team sharing out the questions. Institutions based on collective inquiry, with co-learning, among the participants have been emerging over the past twenty years (Brown and Harris 2014):

- Centres for dialogue e.g. Sweden[2]
- Think tanks e.g. Mt David, USA[3]
- Peak forums e.g. Davos Economic Forum[4]
- Decision-making summits e.g. Copenhagen Davos
- Social movements e.g. Transition Towns[5]
- Global networks e.g. Healthy Cities[6]

The same idea lies in a poem from the seventeenth century:

> *No man is an island; entire of itself...any man's death diminishes me, because I am involved in mankind. And therefore never send to know for whom the bell tolls; it tolls for thee.* John Donne (1607)

In transformation science, the scientific community can return to its central role in an inquiry, although now not alone. Scientists are rather working collectively with the other ways of knowing, either personally or in a group. Having been taught to banish the self from their observations and inquiry methods, in sharing in collective thinking it is time for scientists to put themselves back in the picture. Anthropocentric thought, that is, putting the human position at the centre of their reflections, is traditionally banished by science. Now it becomes a necessary step to recognizing the full range of evidence on any single issue. Humans have no choice but to be anthropocentric, since their very capacity to reflect is a human species characteristic. However, humility lies in recognizing that anthropocentrism is a limitation as well as a human

gift, since human understanding of the world is necessarily limited by the limits of our own thinking (Bohm 1994; Bruner 1986).

As well as accepting partnerships with other ways of knowing, the greatest step in a new direction is to answer the reflective question: 'what does it all mean?' For science, defined by the chemist Medawar as 'the art of the soluble', it is a challenge to reflect on diverse evidence with the recognition that certainty and a final solution are out of the question. For all the questions, some form of synthesis is needed. From a scientist's perspective, one of the outstanding characteristics of the Anthropocene and of transformation science is the move to thinking of the world as a pattern of interconnected systems influenced by human ideas.

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[2] http://centerforinterculturaldialogue.org/
[3] http://www.bates.edu/summit/
[4] http://www.weforum.org/
[5] http://www.transitionnetwork.org/
[6] http://www.euro.who.int/en/health-topics/environment-and-health/urban-health/activities/healthy-cities