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Canada Research Chair
in Integrative Science



**Integrative Science:
a new approach to university science education
and its application in the arena of
community-based natural resource management**

International Workshop on community-based resource management,
organized by: Coady International Institute, StFXU

Unama'ki Institute of Natural Resources, Eskasoni First Nation, NS

17 November 2003



Integrative Science

Toqwa'tu'ki Kjijitaqnn

MI'KMA'KI

Native Council of Nova Scotia
Mi'kmaq Language Program
Artist: Michael J. Martin

What is “Integrative Science”?

Artist
Basma Kavanagh



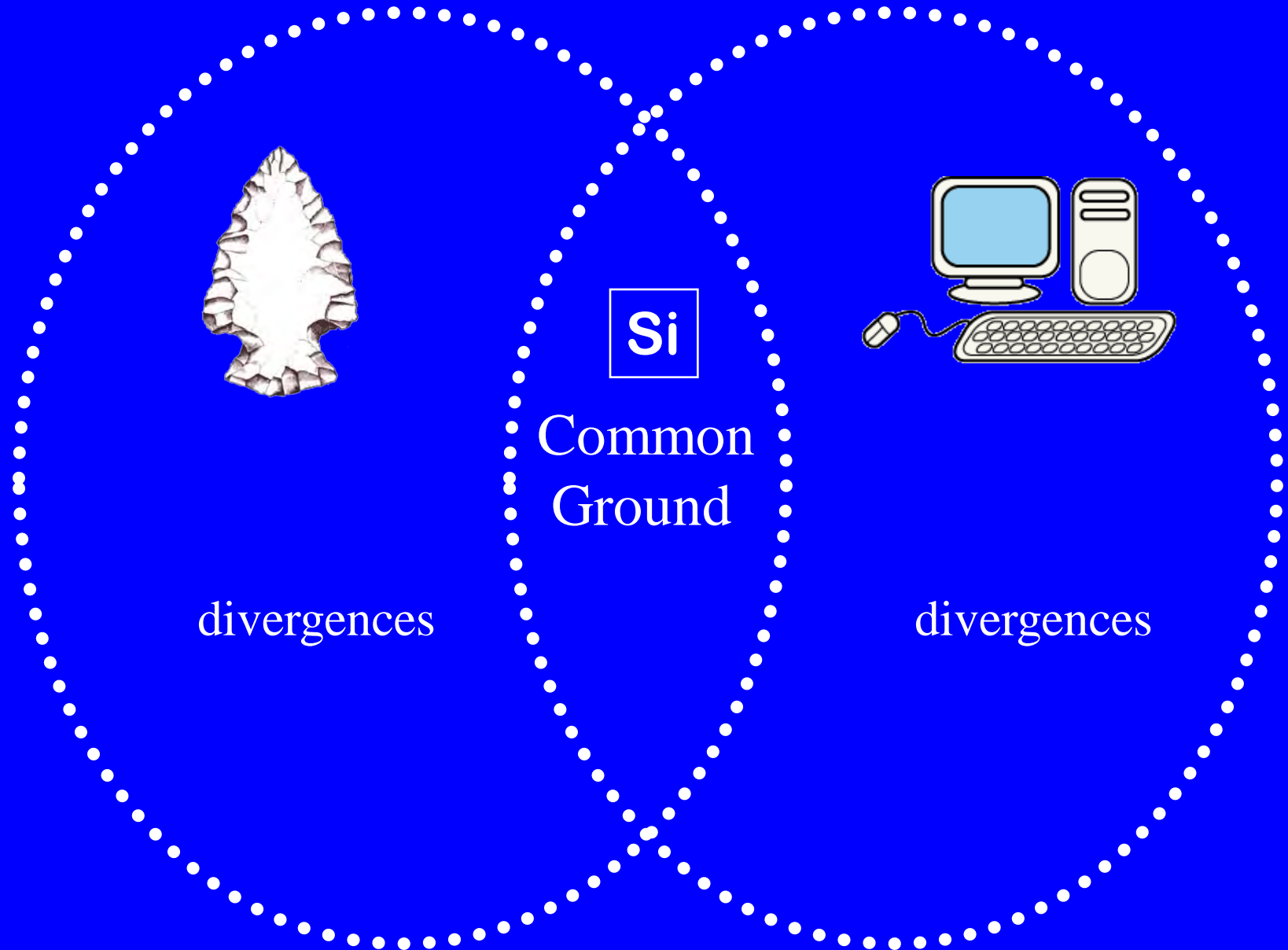
What is “Integrative Science”?

Artist
Basma Kavanagh



“bringing knowledges together”
Aboriginal – Western scientific

Integrative Science: knowledges together



Integrative Science

1

university
science

2

community-based
resource
management

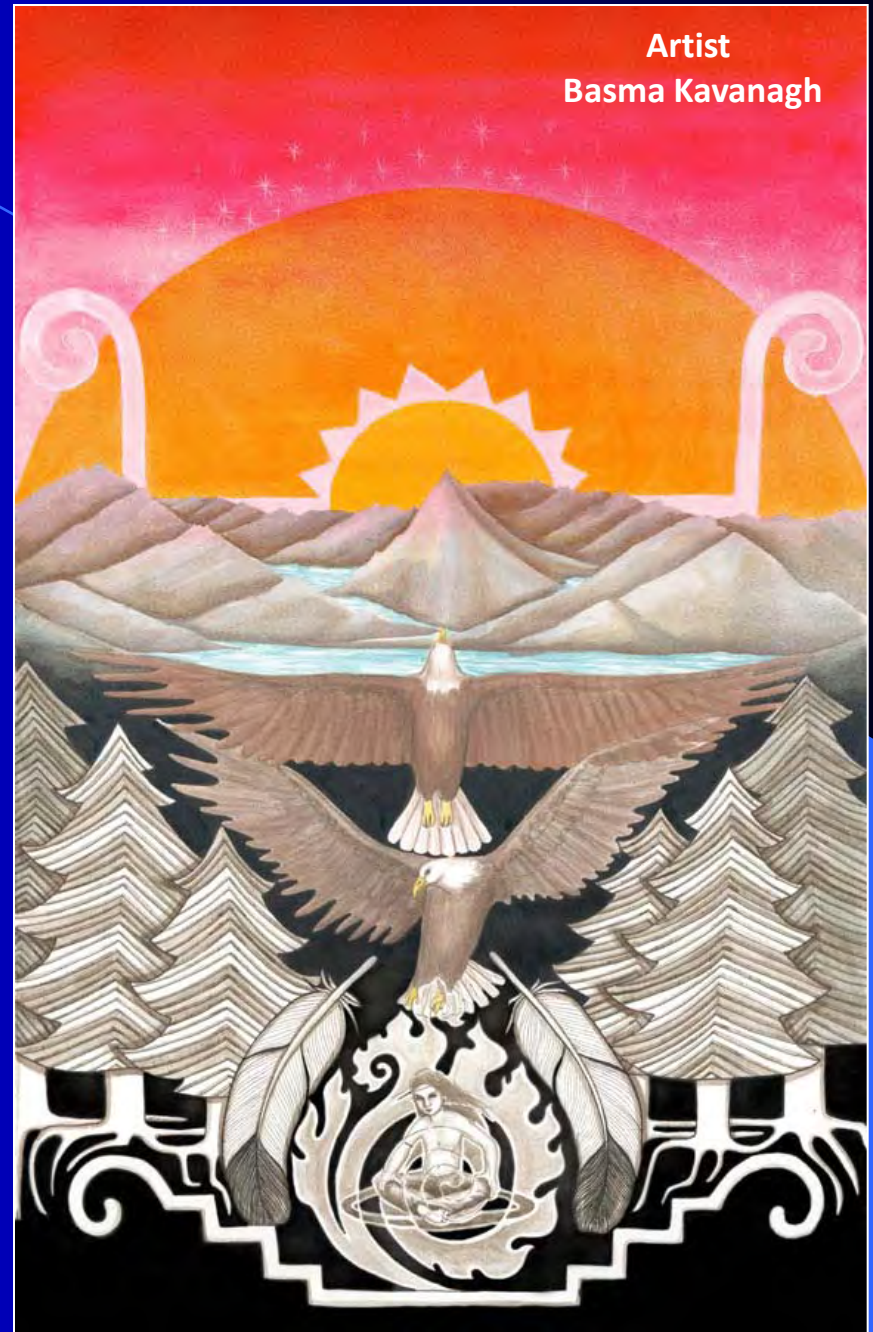
Integrative Science

university
science



4 year
degree program

Artist
Basma Kavanagh



Why?



2. living knowledge

... AK: yes

... WSK education:
more “book-based”

1. spirituality

... AK: yes

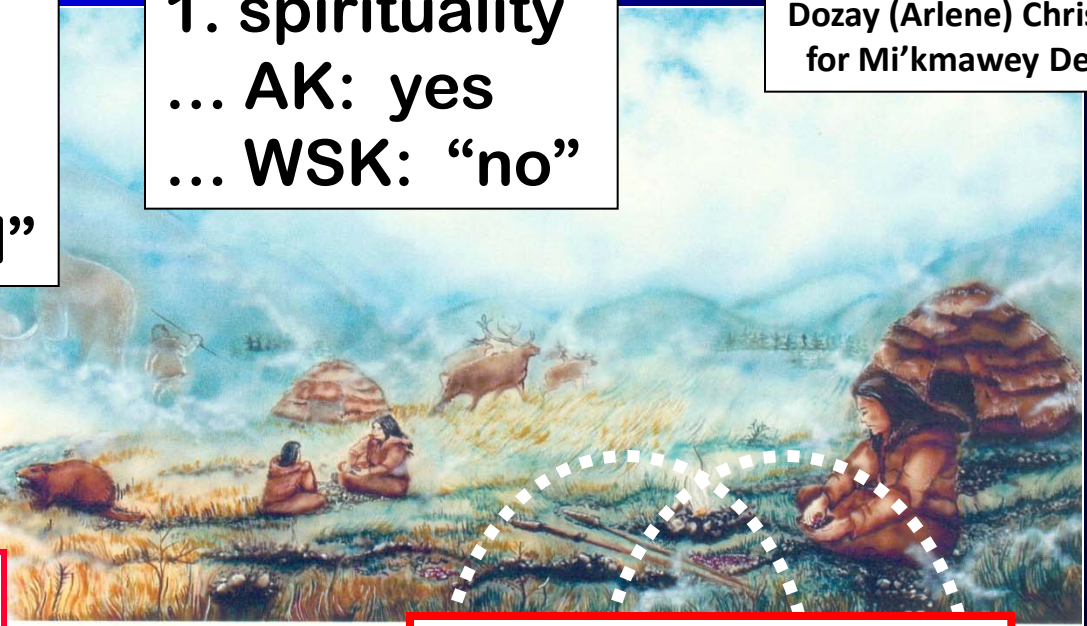
... WSK: “no”

Artist

Dozay (Arlene) Christmas
for Mi'kmawey Debert



AK



many challenges

3. disciplinary fragmentation

... AK: no

... WSK: yes

4. students ...
more familiar
with computers
than nature



WSK



HOW?

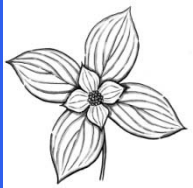


1

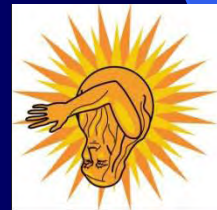
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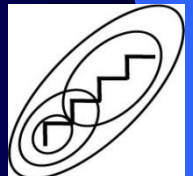
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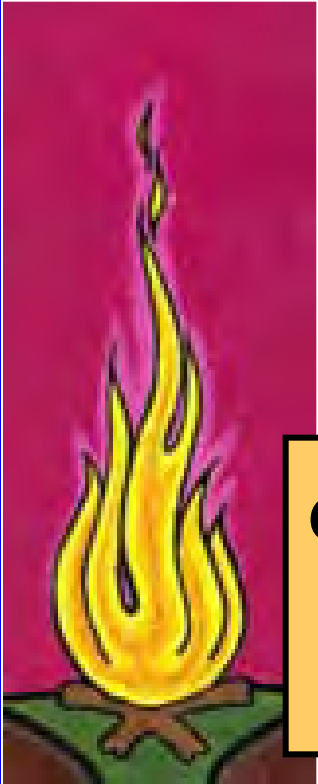


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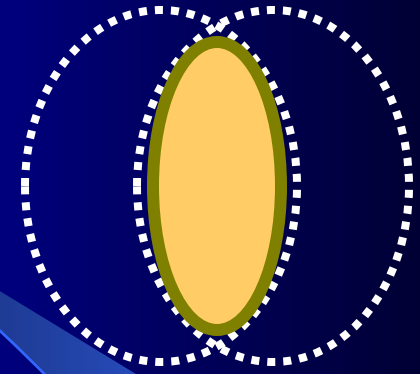
6

common ground
and
differences





**Mother
Earth**



PATTERNS

common ground
PATTERN RECOGNITION

Both knowledge systems are ultimately
based on observations of the **environment**
and both result from the same intellectual
process of creating order out of disorder.

common ground
PATTERN RECOGNITION

PATTERNS



**Mother
Earth**

recognize / make / break
express / use

recognize / make / break
express / use / transform

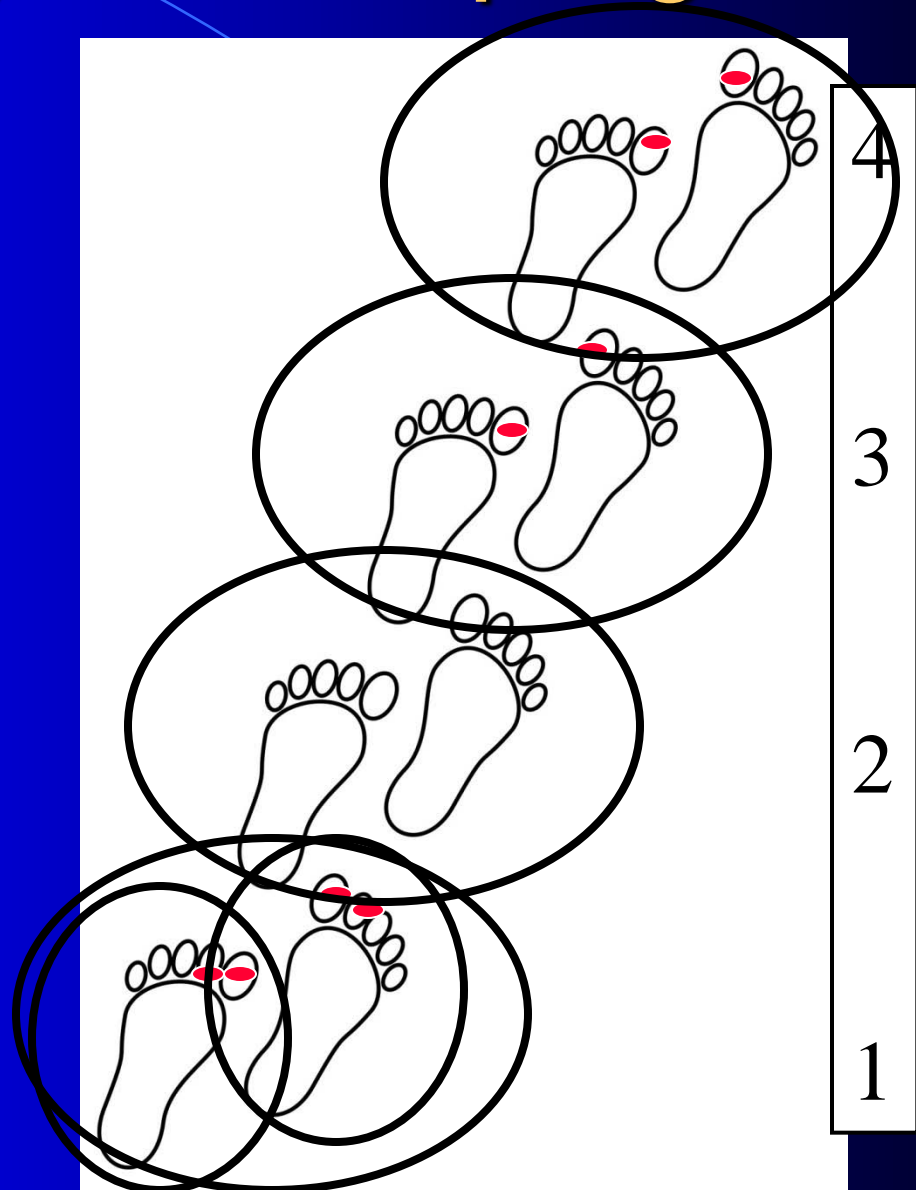
4 yr university BScCS program

MSIT courses



PATTERN

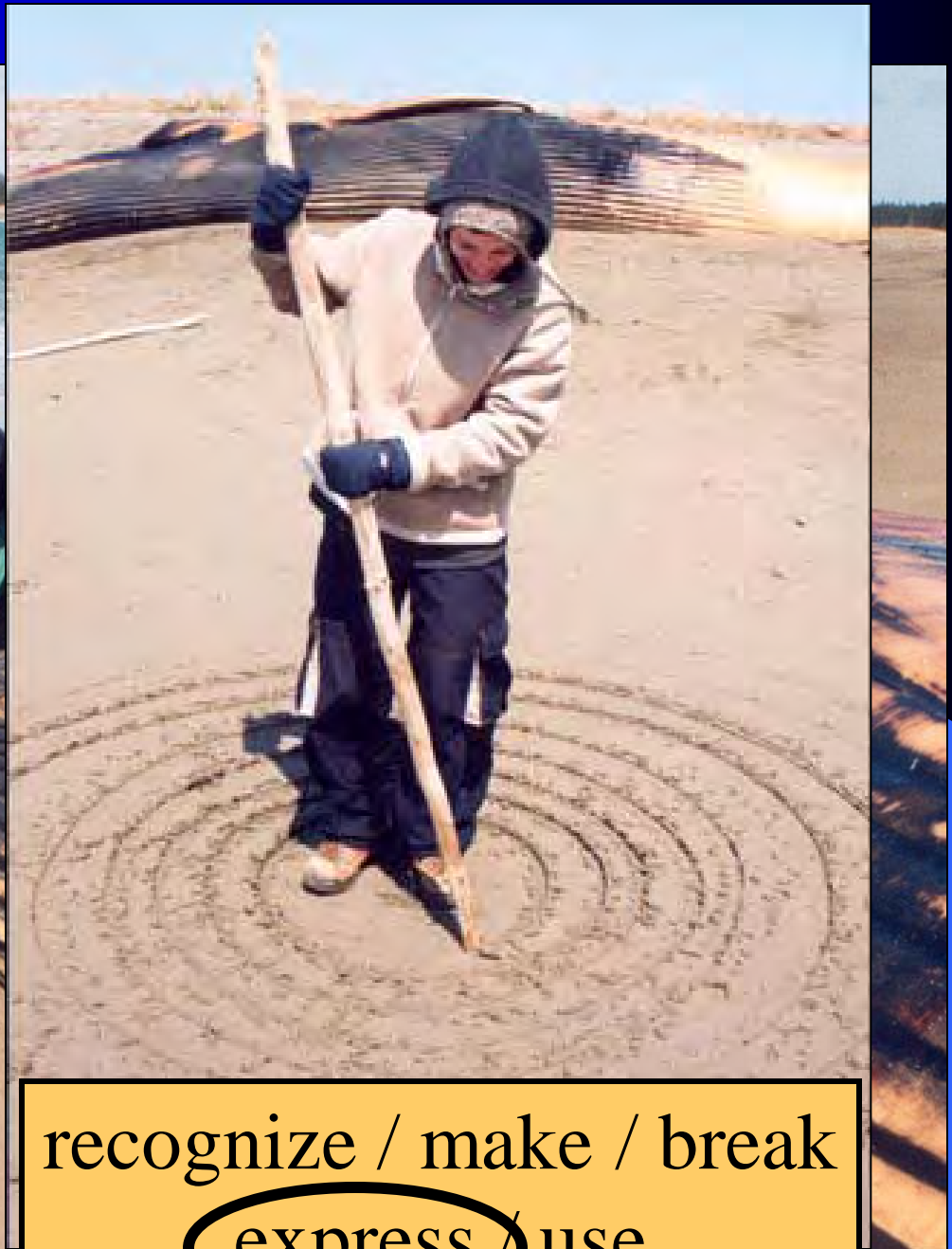
Artist Basma Kavanagh





**Mother
Earth**

PATTERNS



recognize / make / break
express / use

“expression smarts” for **PATTERN**



- numbers
- language

recognize / make / break
express / use

-
- music
 - body
 - art
 - other people
 - self
 - naturalist

-
- spiritual

**expression
tied to
cultural
value**



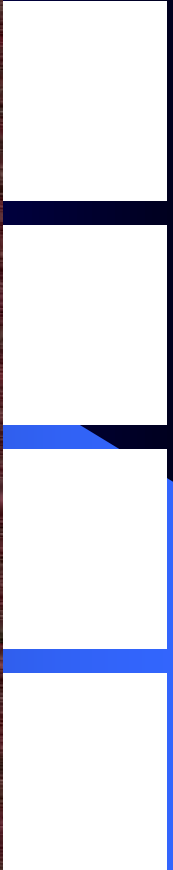
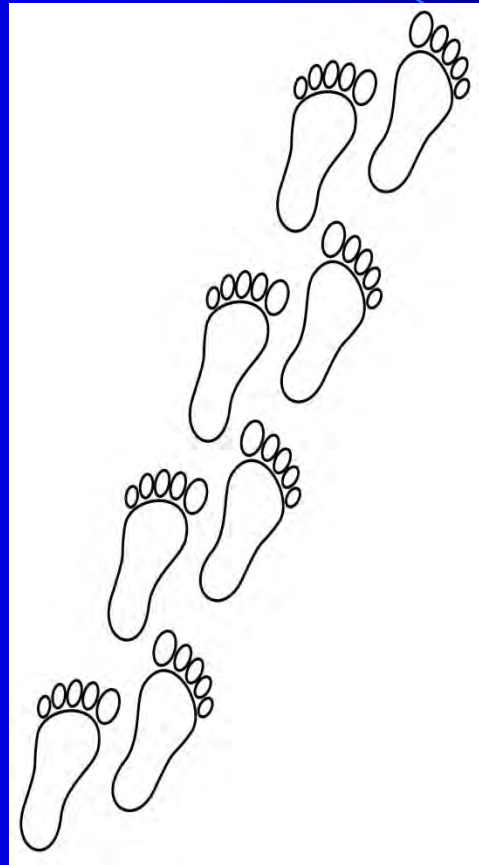
PATTERN

conceptual framework

natural

ideal

abstract



**Mother
Earth**

recognize / make / break
express / use

expression tied to
cultural value

abstract pattern

ideal pattern

Mother
Earth

natural pattern

PATTERN



value Earth

respectful & participatory
interconnectedness

masterful
prediction & control

all my relations pattern

mathematical pattern

expression tied to
cultural value

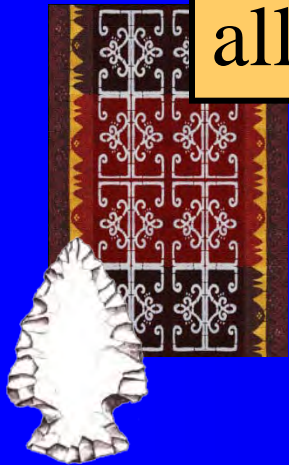
abstract pattern

ideal pattern

Mother
Earth

PATTERN

natural pattern





respectful & participatory interconnectedness

Medicine Wheel ... based on layered pattern:

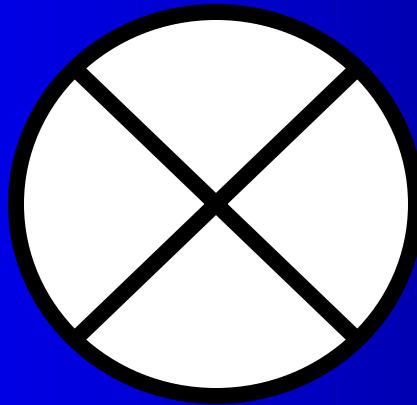
natural



ideal



abstract



PATTERN

natural

← ADD

ideal

← ADD

abstract

ideal

natural

(layering)

Medicine Wheel Representations

N
(Cognitive)



in the **patterns** of the animals
... lessons for humans

PATTERN





in the patterns of the animals
... lessons for humans

PATTERN



Euplectella aspergillum
from the Invertebrate
Collection of the
National Museum of
Natural Sciences,
Madrid, Spain.

Fibre-optical features of a glass sponge

Some superior technological secrets have come to light from a deep-sea organism.

Modern technology cannot yet compete with some of the sophisticated optical systems possessed by biological organisms¹⁻³. Here we show that the spicules of the deep-sea 'glass' sponge *Euplectella* have remarkable fibre-optical properties, which are surprisingly similar to those of commercial telecommunication fibres — except that the spicules themselves are formed under normal ambient conditions and have some technological advantages over man-made versions.

The skeleton of the hexactinellid class of sponges is constructed from amorphous, hydrated silica⁴⁻⁶. *Euplectella* builds an intricate cage (Fig. 1a), which typically houses a mating pair of shrimp (hence its nickname, 'Venus flower-basket') and is composed of a lattice of fused spicules⁷ that provide extended structural support.

A network of anchorage spicules (basalia) extend outwards in a crown-like formation. These spicules are generally 5–15 cm long and 40–70 µm in diameter; their native cross-section is homogeneous and they have no structural boundaries. Under stress or etching, the spicules reveal a characteristic layered morphology⁸ and cross-sectional variations in composition that appear as three distinct regions: a pure silica core of about 2 µm in diameter that encloses an organic filament; a central cylinder that has the greatest organic content of the three; and a striated shell that has a gradually decreasing organic content and which is glued together by organic films (Fig. 1b).

We anticipated that the spicules' rich substructure should be reflected in their optical properties as well. Indeed, interferometric refractive-index profiling⁹ revealed three regions that correspond to the three regions of structural composition (Fig. 1c): a core with high refractive index that is comparable to (or higher than) that of vitreous silica; a cylinder of lower refractive index that surrounds the core; and an oscillating pattern with progressively increasing refractive

index between the spicule and air (Fig. 1d, right).

These biological fibres therefore resemble commercial telecommunication fibres, in that they are made of the same material and have comparable dimensions, as well as similar refractive indices for the high-index core and a low-index cladding. They also function as efficient single-mode, few-mode or multi-mode waveguides, depending on the optical launch conditions.

The principal weakness of commercial optical fibres is that they fracture as a result of crack growth, whereas the spicules' lamellar layers, connected by organic ligands at the fibre's exterior, provide an effective crack-arresting mechanism and enhance fracture toughness^{2,3}. Another superior feature of the spicules is their formation under ambient conditions, a process that is regulated by organic molecules^{10,11}. This ambient-temperature process, unlike the high-temperature manufacture of man-made fibres, allows the structure to be doped with specialized impurities that improve the refractive index and therefore the wave-guiding properties. Our preliminary elemental analysis

shows, for example, that sodium ions are present throughout the spicules, particularly in the core. Although sodium ions (and many other additives) are desirable fibre-optic dopants, they present a manufacturing challenge, for example by causing devitrification at high temperatures.

Our results suggest the intriguing possibility that the spicules of *Euplectella*, beyond structural anchorage support, could also provide a highly effective fibre-optical network, which may be useful in distributing light in its deep-sea environment. This illuminating sponge should also shed light on low-temperature, biologically inspired processes that could give rise to better fibre-optical materials and networks.

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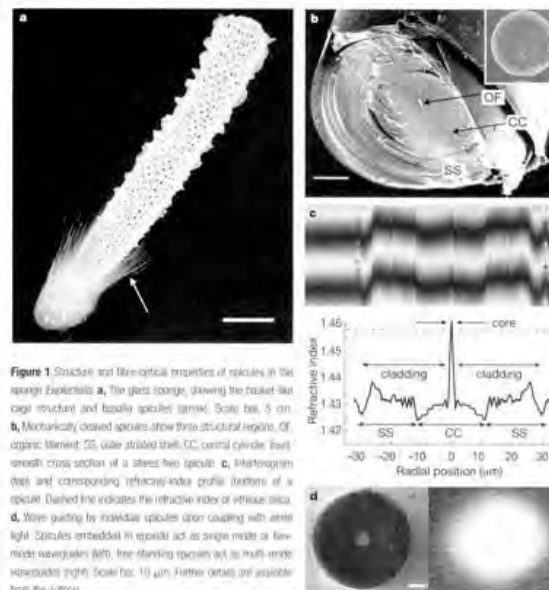
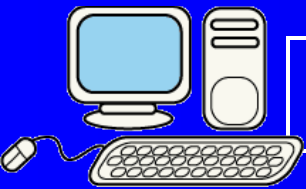


Figure 1 Structure and fibre-optical properties of spicules in the sponge *Euplectella*. **a**, The glass sponge, showing the basket-like cage structure and basalia spicules (arrow). Scale bar, 5 cm. **b**, Mechanically cleaned spicules show three structural regions: OF, organic filament; SS, outer striated shell; CC, central cylinder. Inset shows smooth cross section of a stress-free spicule. **c**, Interferogram (left) and corresponding refractive index profile (bottom) of a spicule. Dashed line indicates the refractive index of vitreous silica. **d**, Wave guiding by individual spicules upon coupling with white light. Spicules embedded in epoxide act as single mode or few-mode waveguides (right). Inset shows spicules act as multi-mode waveguides (right). Scale bar, 10 µm. Further details are available from the authors.



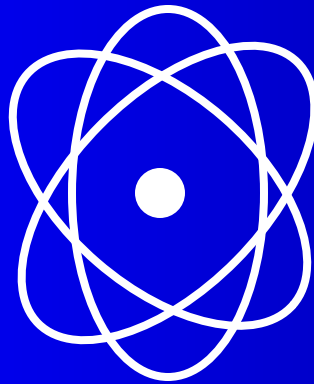
masterful prediction & control

Periodic Table ... based on layered pattern:

natural

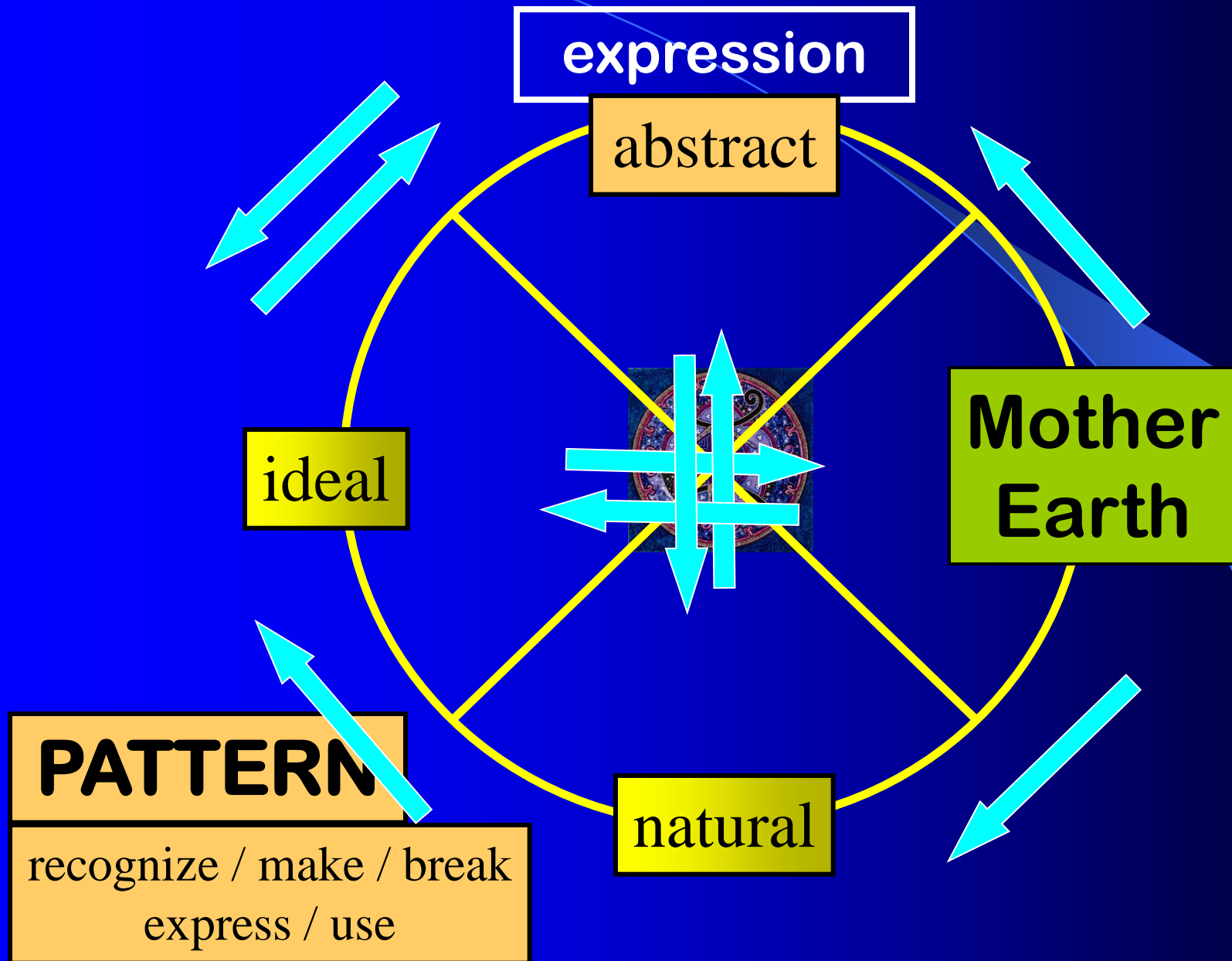
ideal

abstract

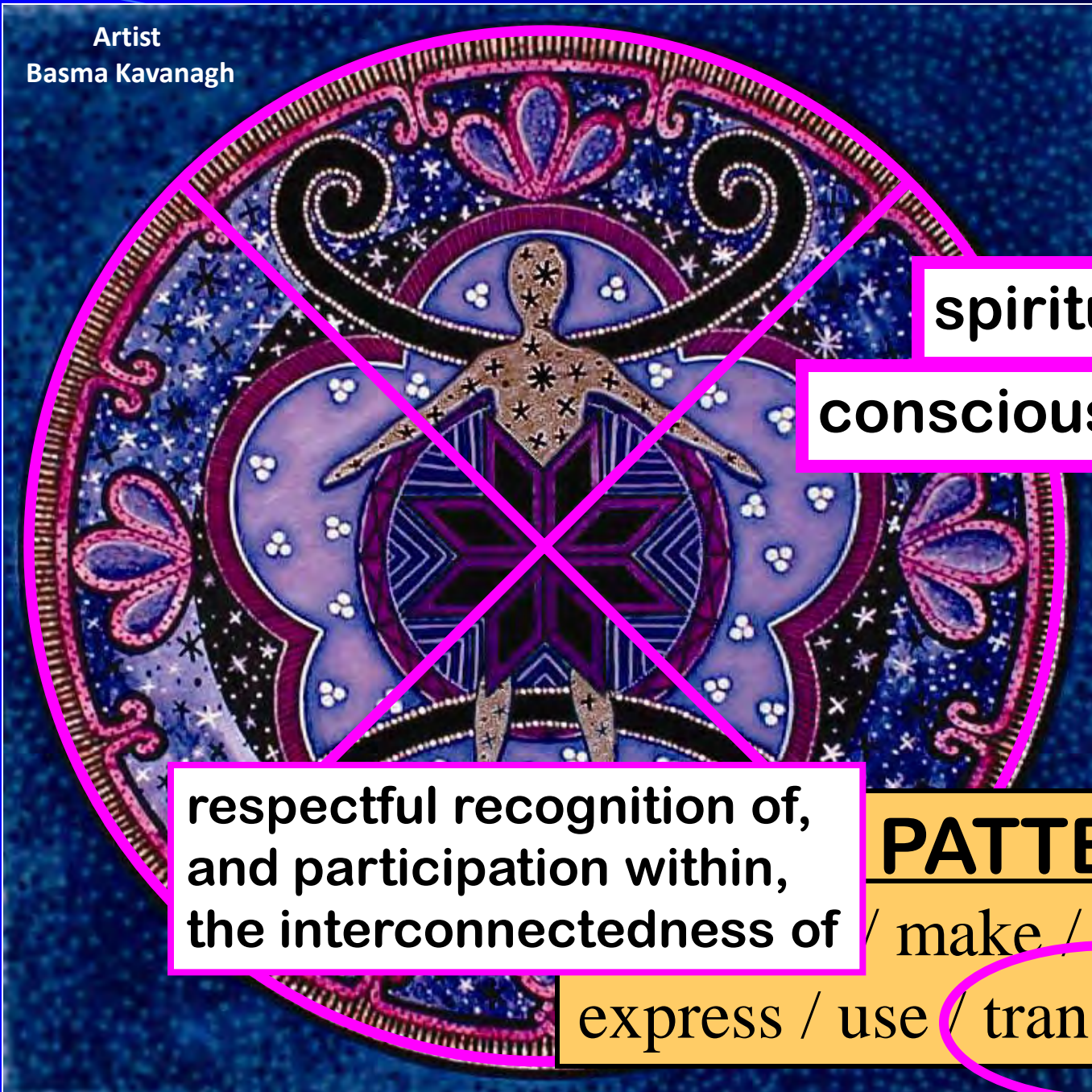


PATTERN

Setford, Steve. 1996. Science Facts. Firefly Books Ltd., Willowdale, ON. (pp. 36-37)



Artist
Basma Kavanagh



spirituality

consciousness



respectful recognition of,
and participation within,
the interconnectedness of

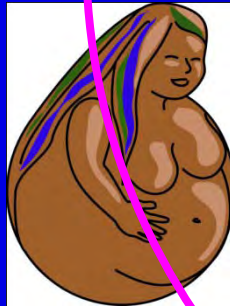
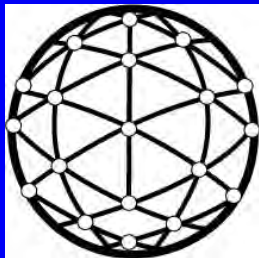
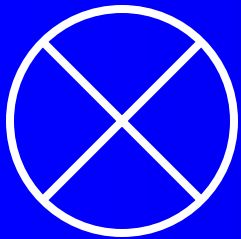
PATTERN

make / break

express / use / transform

PATTERN TRANSFORMATION

inner – outer – inner – outer



expanding sense of wholeness
... pattern within pattern



awareness

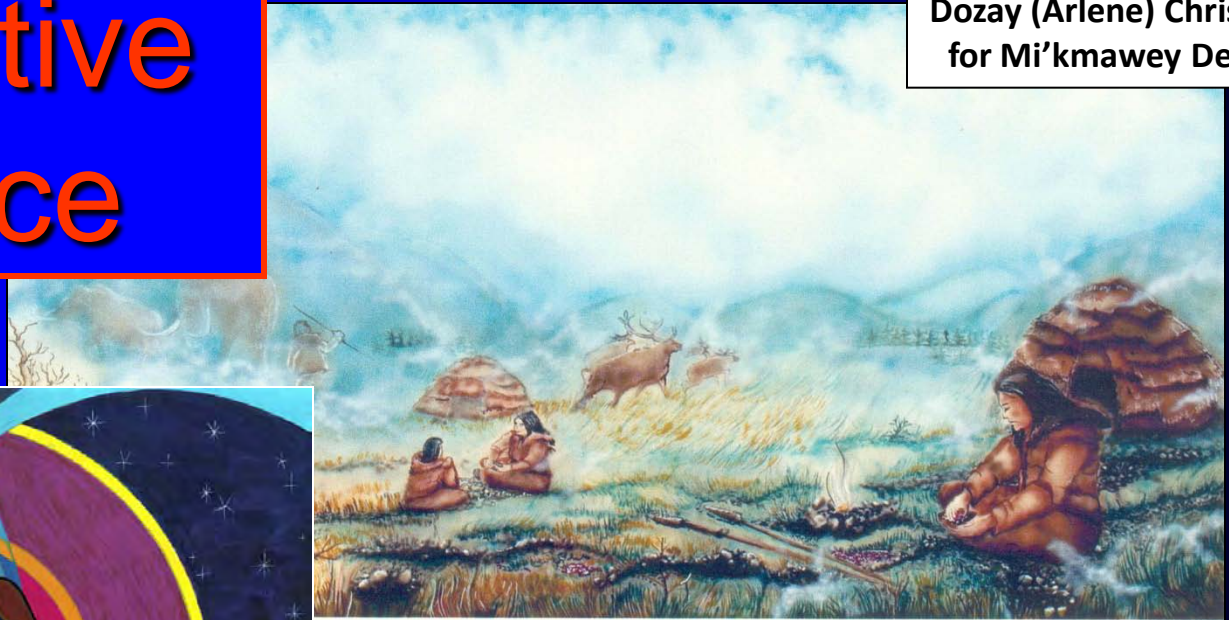
**questions
patterns
metaphors**

PATTERN

Artist Basma Kavanagh

Integrative Science

Artist
Dozay (Arlene) Christmas
for Mi'kmawey Debert



1

university
science

unknown



FEAR

known

Mother Earth
... especially, patterns
of the animals



“must become PATTERNable”

Integrative Science

2

community-based
resource
management

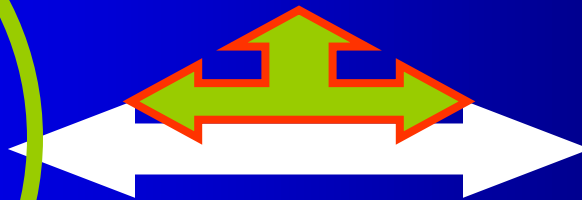


communities in:
Bras d'Or Lakes
and Watershed
ecosystem

“Sense of Place”

“Sense of Place”

Integrative Science



drawing upon work by
Integrative Science Research Assistants
Nadine Lefort and Sana Kavanagh



communities in:
Bras d'Or Lakes
and Watershed
ecosystem



MI'KMA'KI

Native Council of Nova Scotia
Mi'kmaq Language Program
Artist: Michael J. Martin

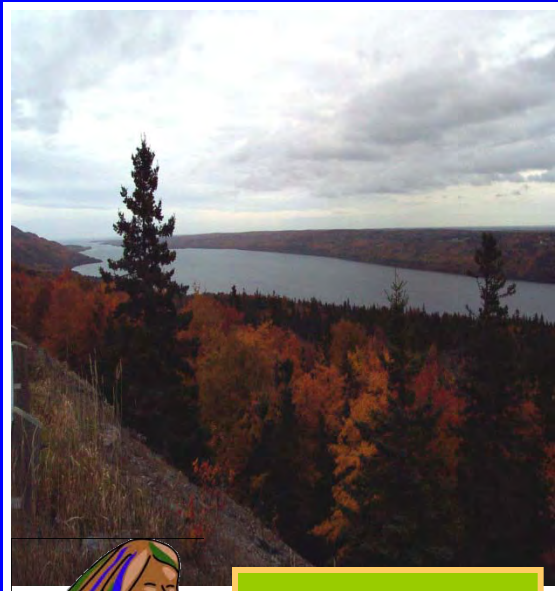
PATTERN | conceptual framework

conceptual framework

natural

ideal

abstract



45°48" - 47°13"
59°42" - 61°57"

Place



“Sense of Place”

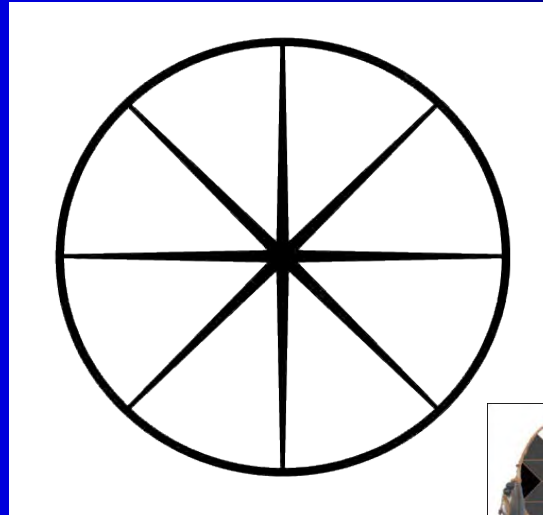
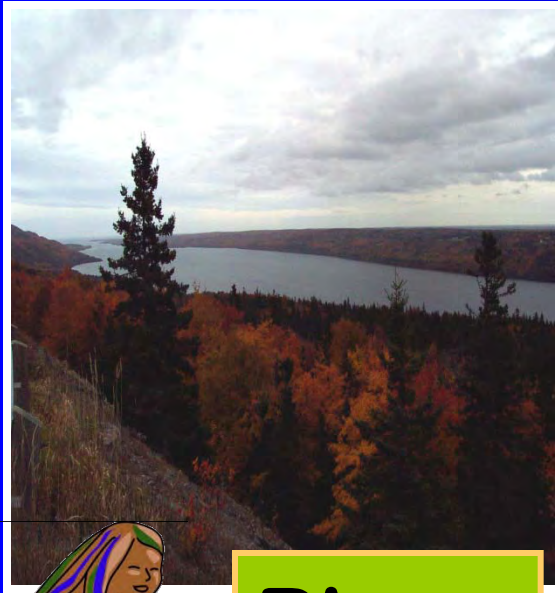
PATTERN

conceptual framework

natural

ideal

abstract



Place



“Sense of Place”

Medicine Wheel



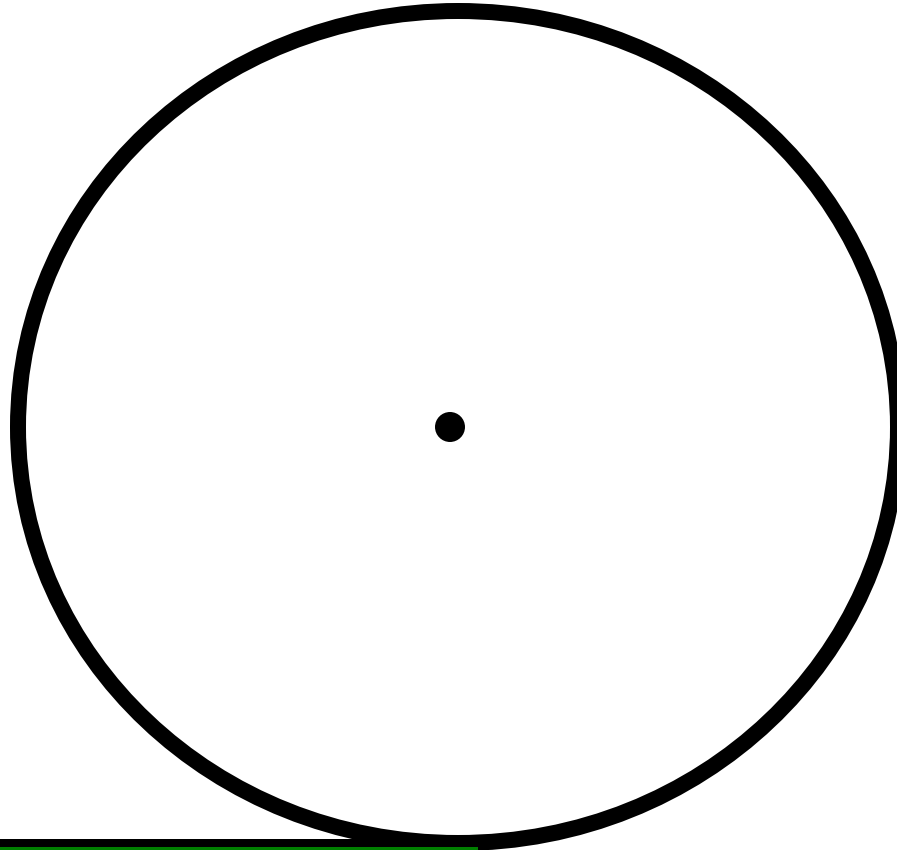
“Sense of Place”

self



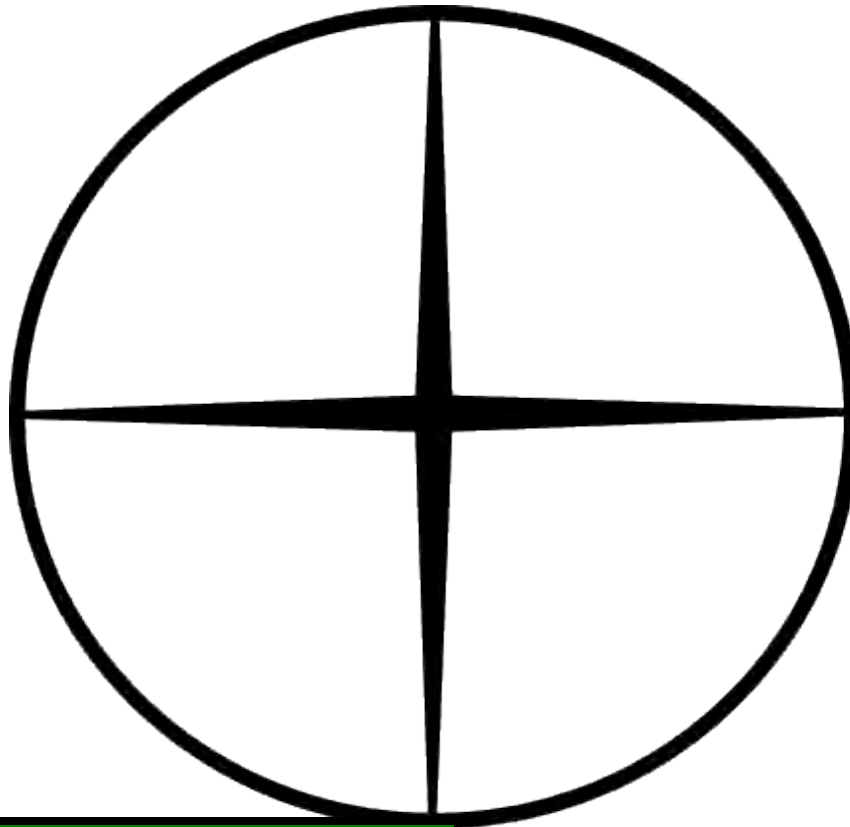
“Sense of Place”

personal



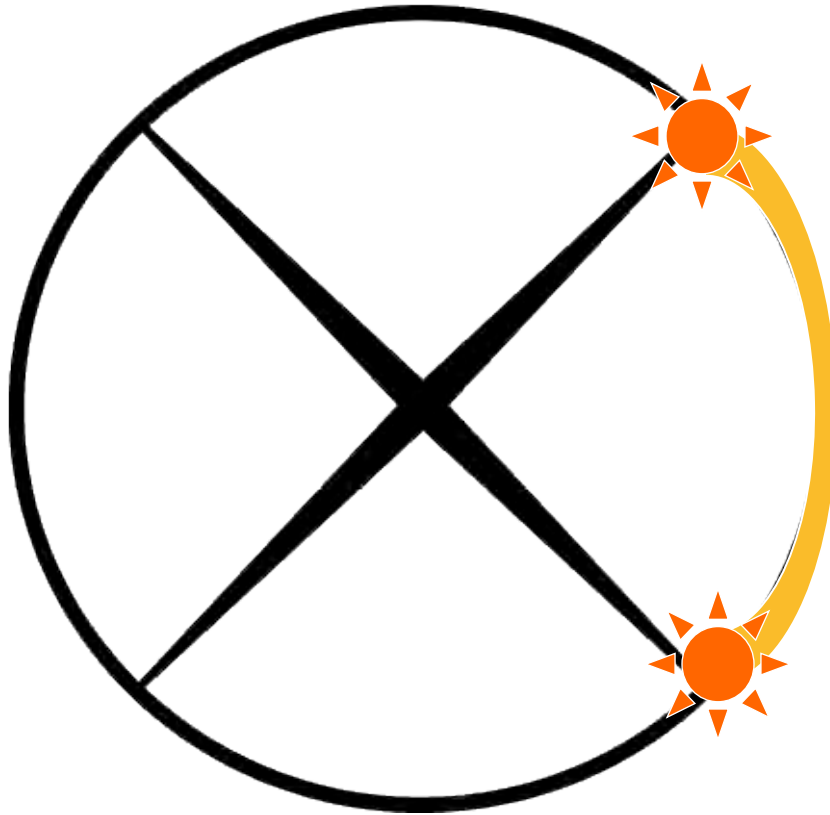
“Sense of Place”

directional



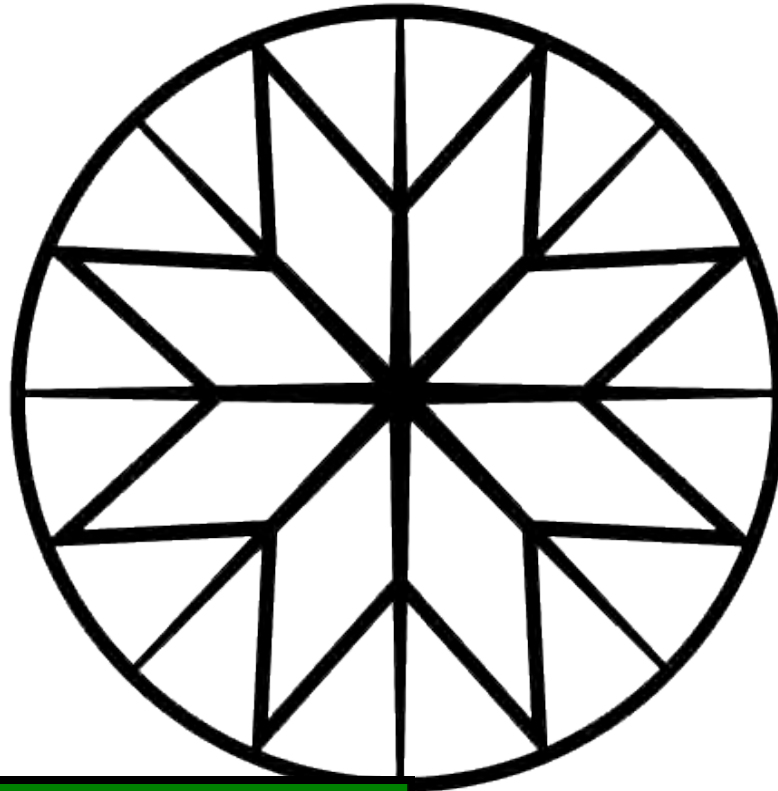
“Sense of Place”

temporal

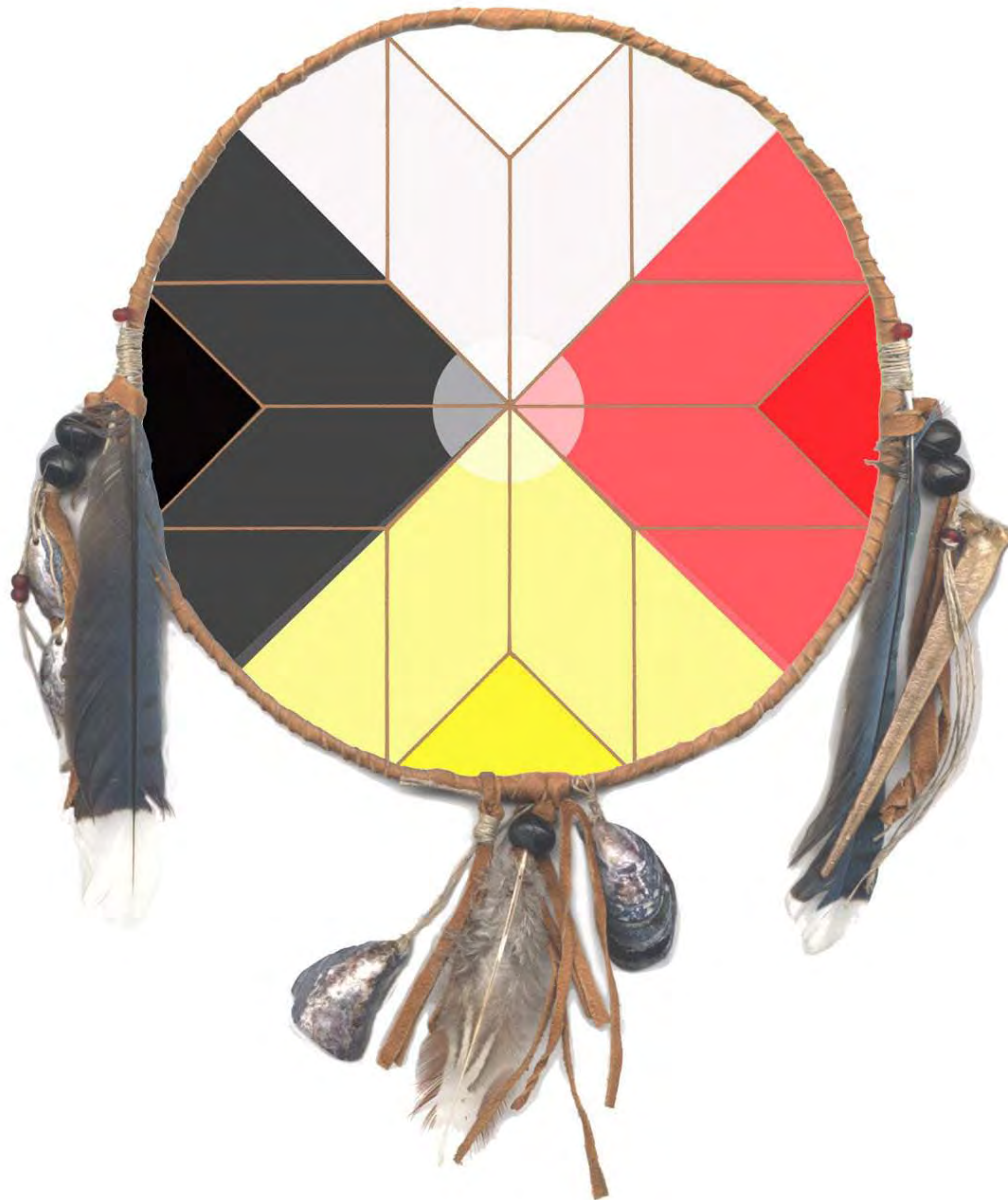


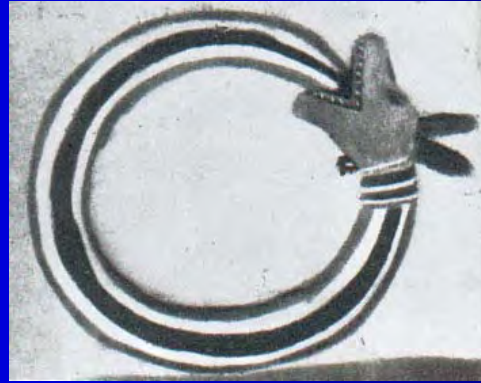
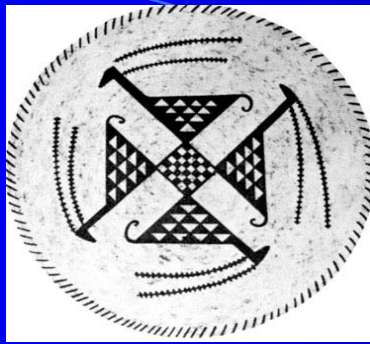
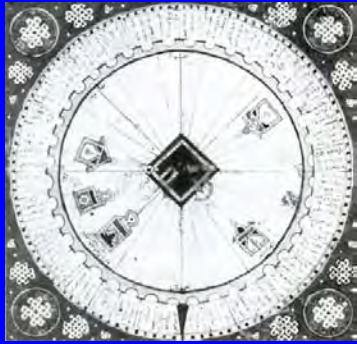
“Sense of Place”

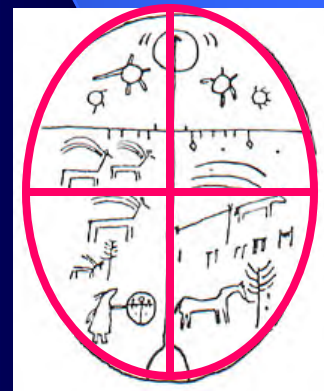
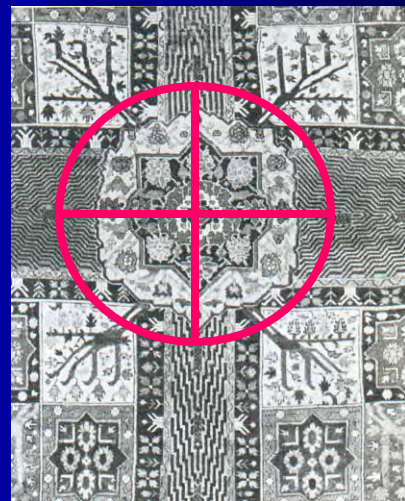
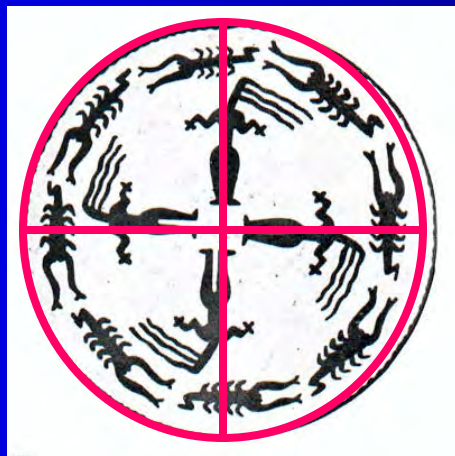
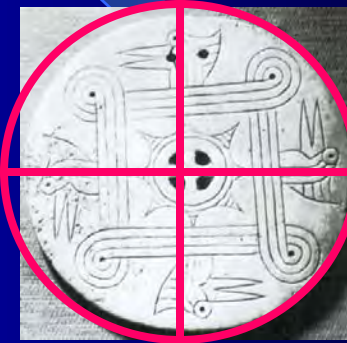
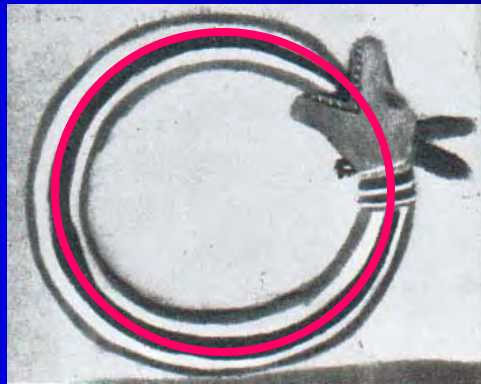
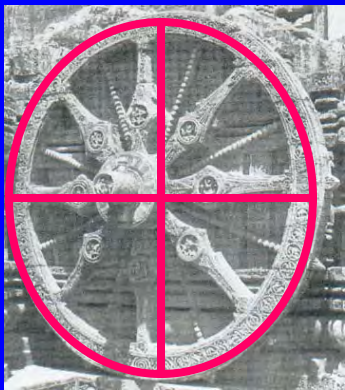
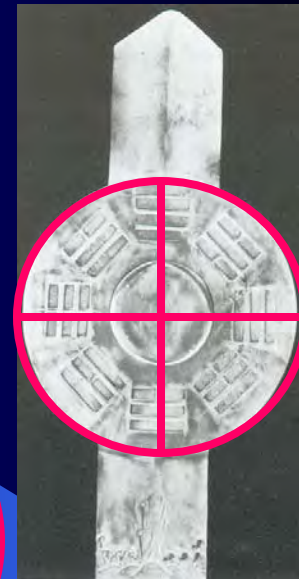
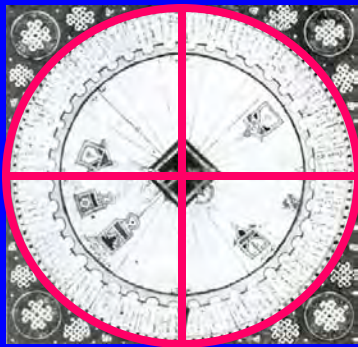
cultural



“Sense of Place”







“Sense of Place”

e.g. food fishery



“Sense of Place”



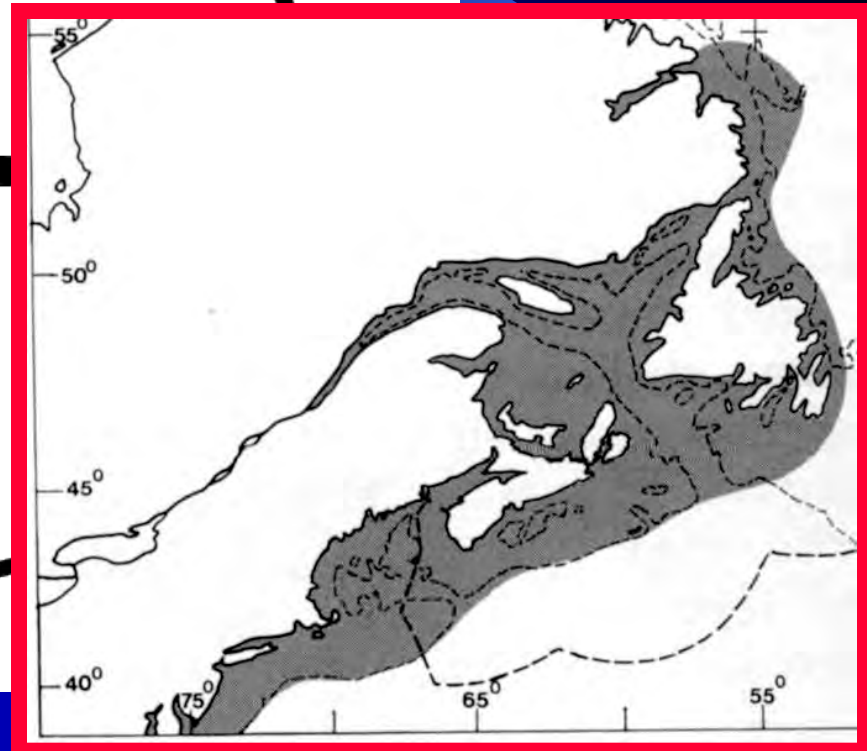
“Sense of Place”

**self &
personal**



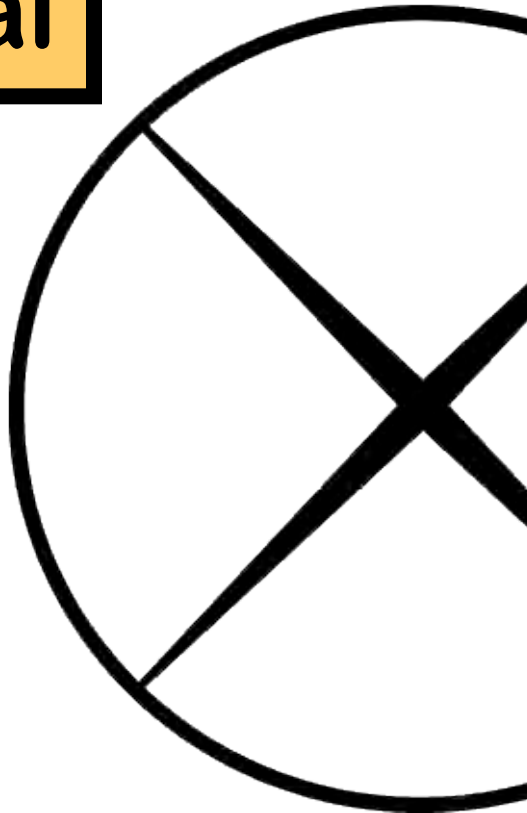
“Sense of Place”

directional



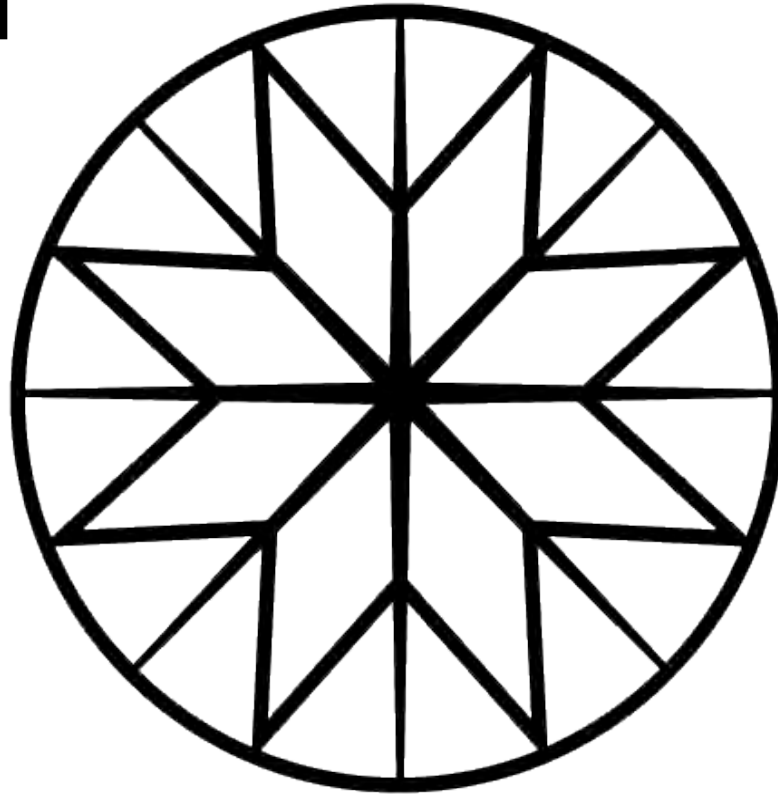
“Sense of Place”

temporal



“Sense of Place”

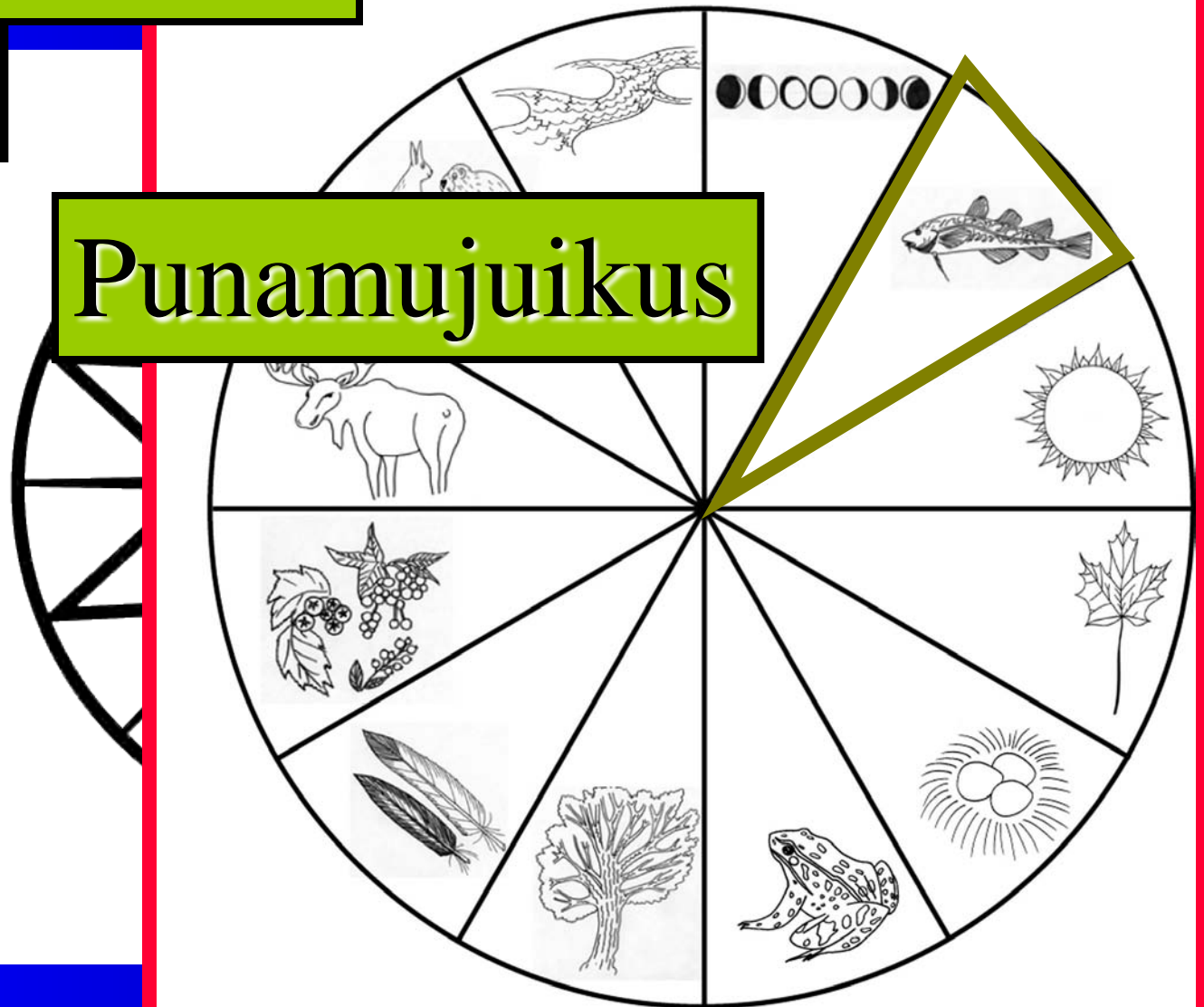
cultural



“Sense of Place”

cultural

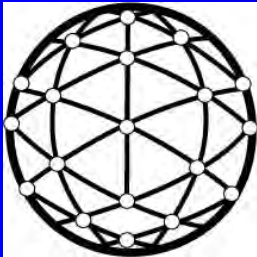
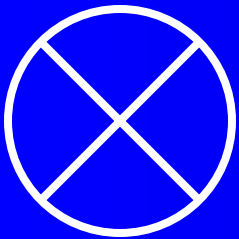
Punamujuikus



"Sense of Place"

PATTERN TRANSFORMATION

inner – outer – inner – outer



expanding sense of wholeness
... pattern within pattern



Pattern within pattern

- relationship
- respect
- reverence
- reciprocity
- ritual
- repetition
- responsibility

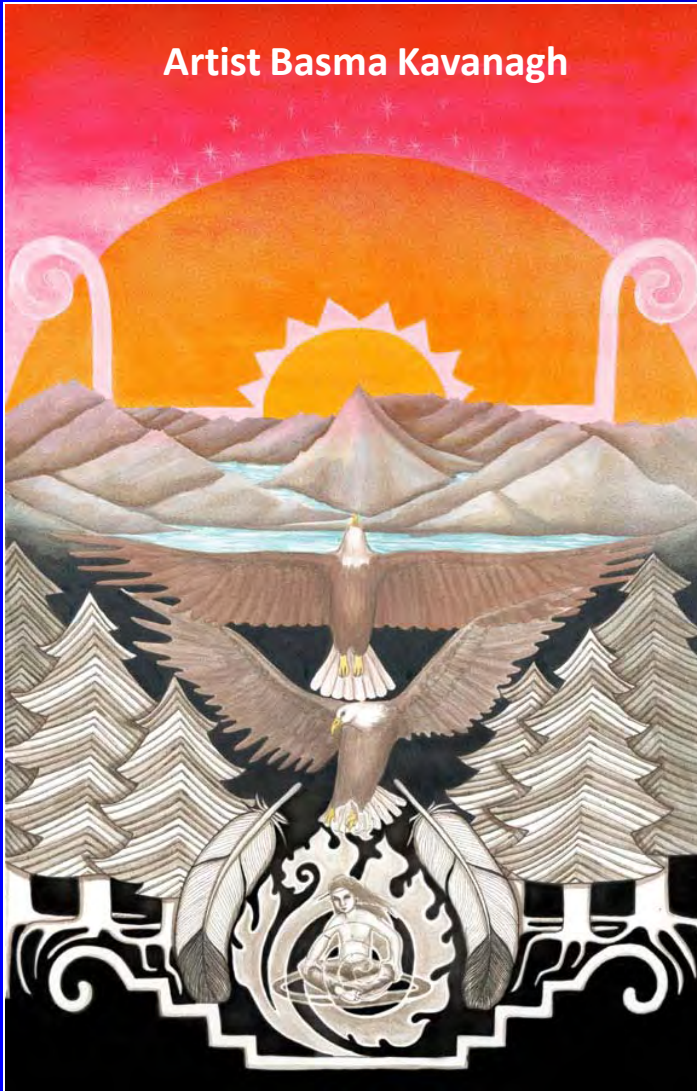
Artist Basma Kavanagh



“Sense of Place”

relevance of “Sense of Place”

Artist Basma Kavanagh



Community

Resource management

Health

Spirituality

Stewardship

Environmental issues

Ecology

Respect

Reverence

Artist Basma Kavanagh



Canada Research
Chairs

Chaires de recherche
du Canada

acknowledgments



**Mi'kmaq students,
Elders, and
communities**



Thank you
Wela'lioq

Artist Basma Kavanagh

