

# Cheryl Bartlett

Professor of Biology  
Canada Research Chair  
In Integrative Science



## Integrative Science / Toqwa'tu'kl Kijijitaqnn

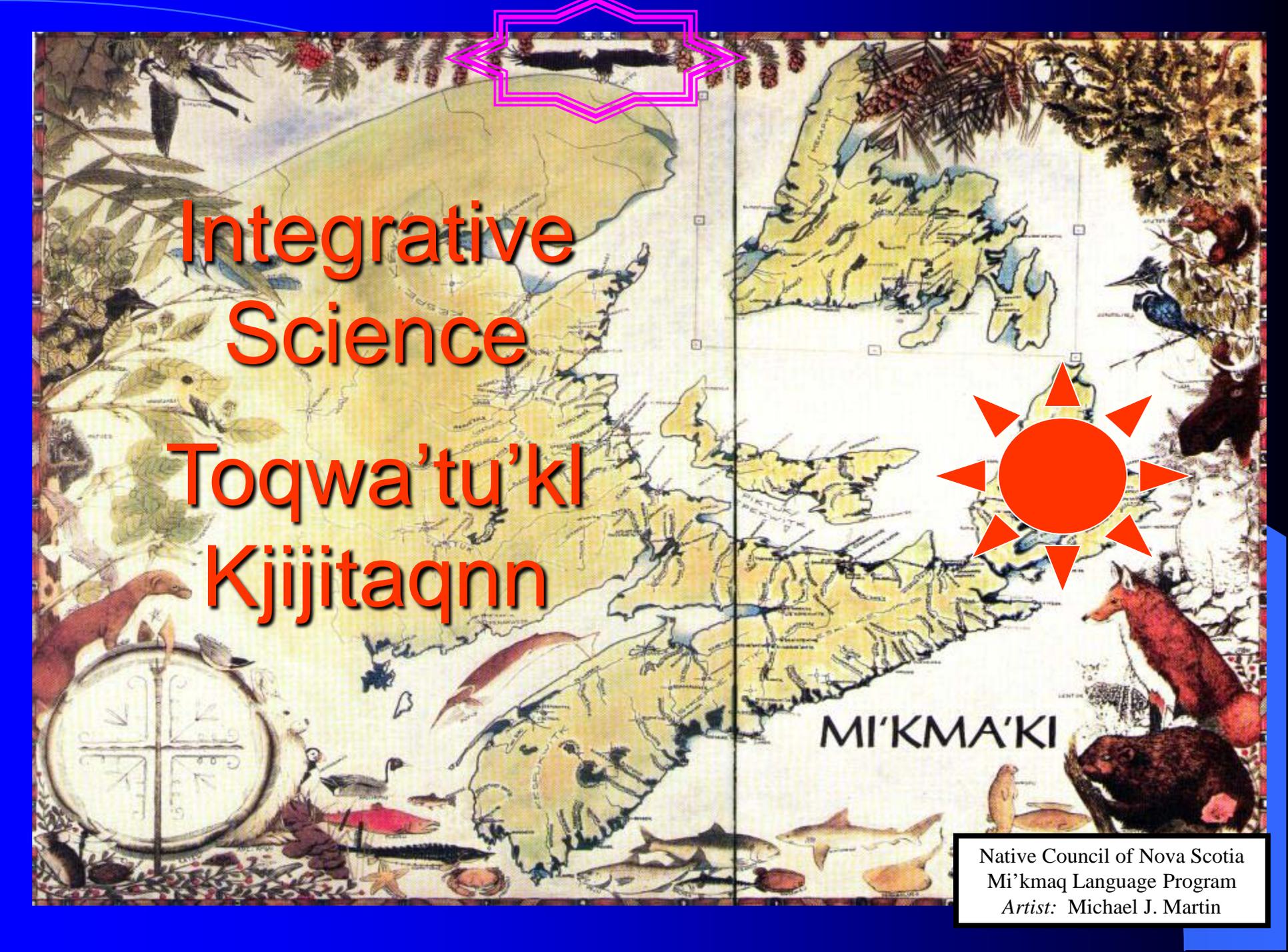
*presentation for:*

Mi'kmawey Debert

Elders' Advisory Board Meeting  
26 March 2004; Millbrook, NS



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



# 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

university  
science



4 year  
degree program



artist Basma Kavanagh



What else ... ?  
**Integrative  
Science**





What else ... ?  
**Integrative  
Science**



What is

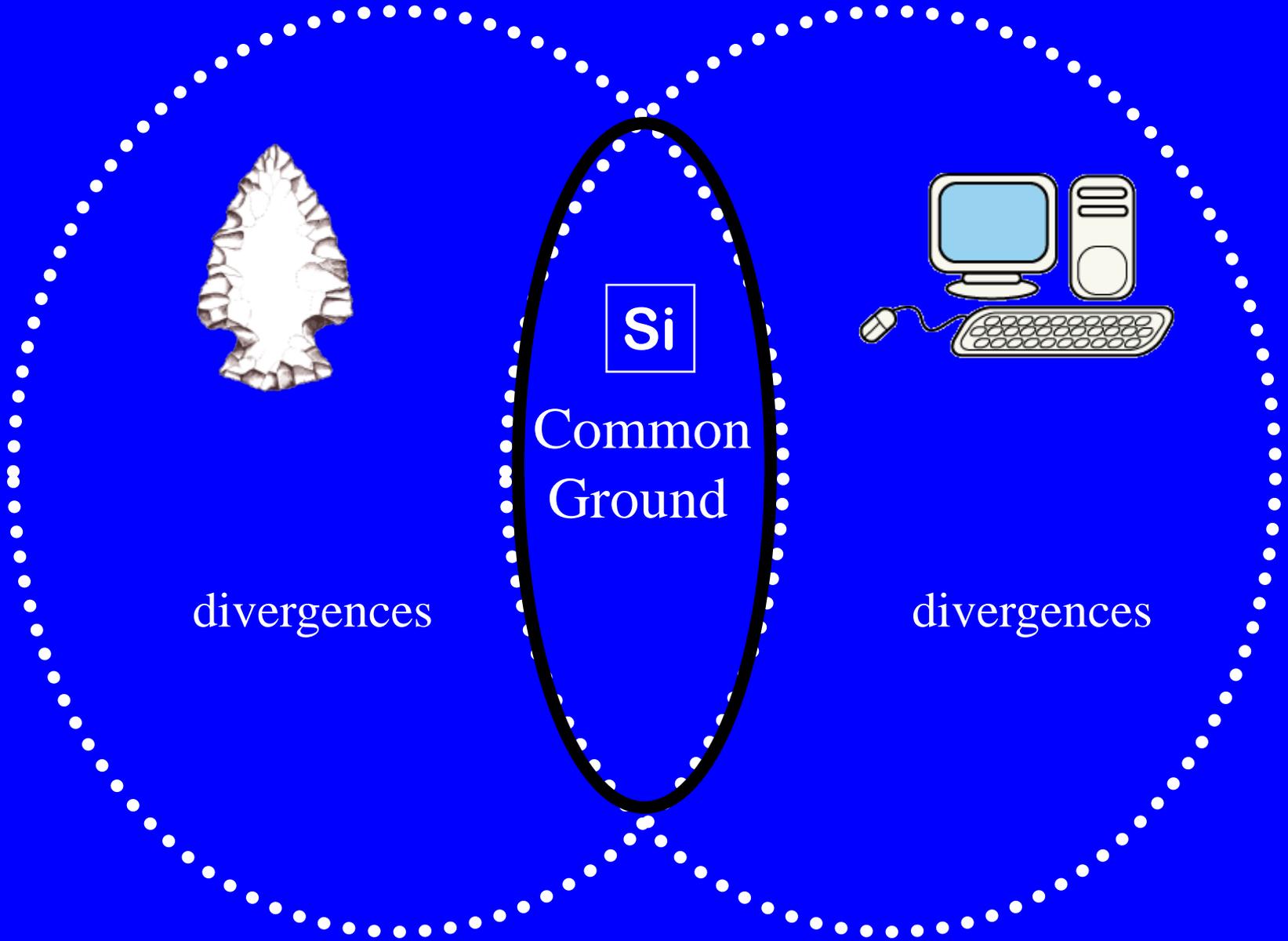
# Toqwa'tu'kl Kijitaqnn

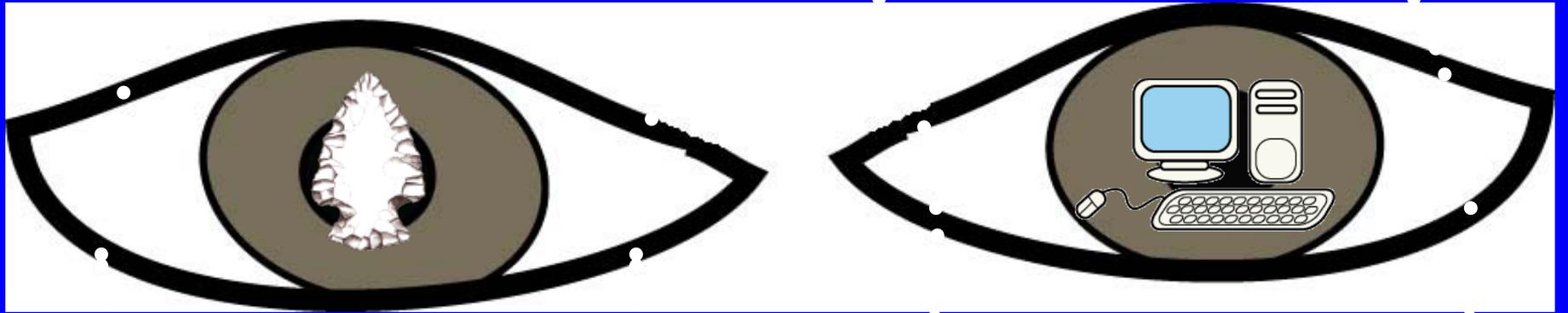


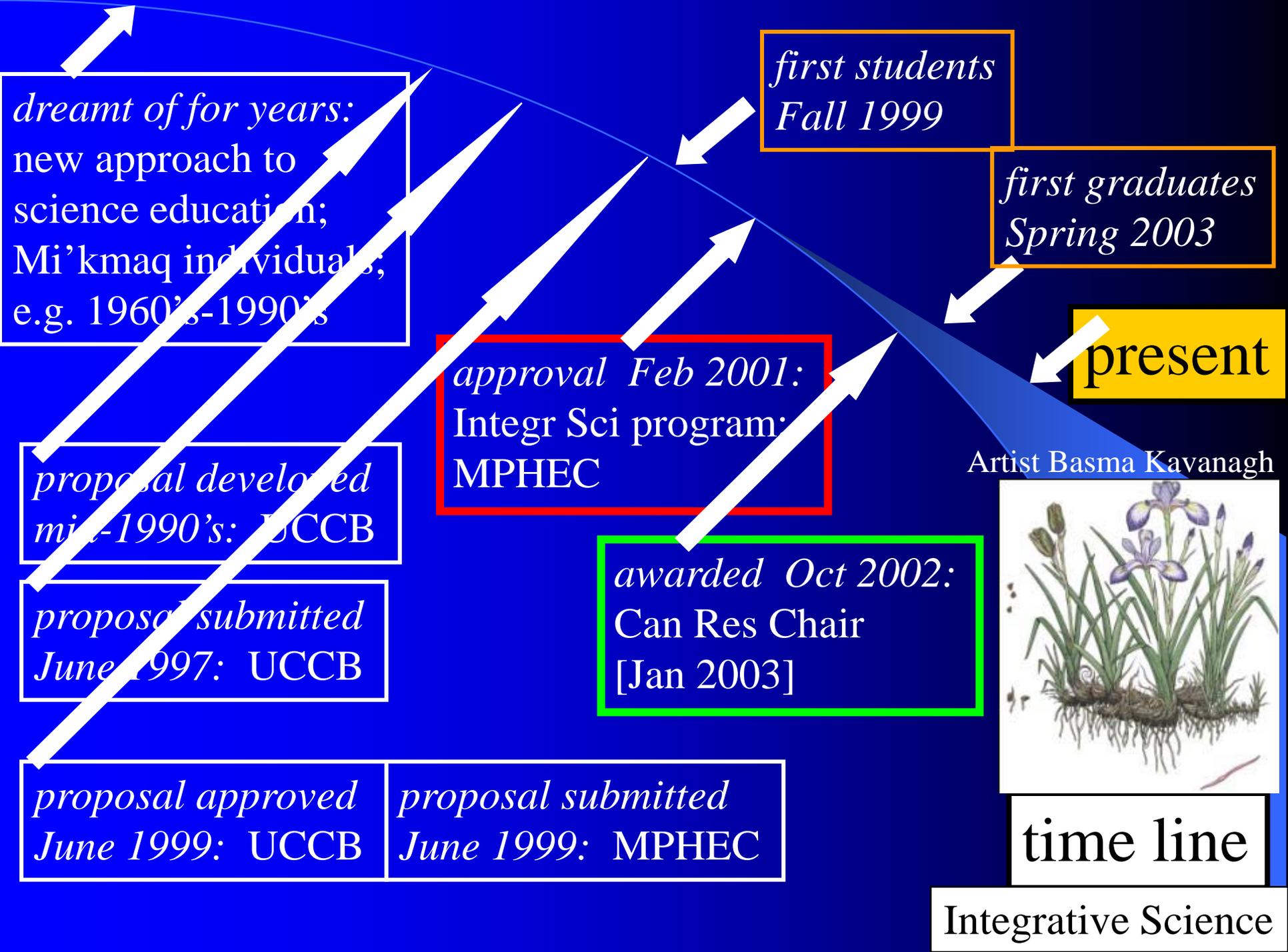
artist  
Basma  
Kavanagh

“bringing knowledges together”  
Aboriginal – Western scientific

# Integrative Science: knowledges together







*dreamt of for years:  
new approach to  
science education;  
Mi'kmaq individuals;  
e.g. 1960's-1990's*

*first students  
Fall 1999*

*first graduates  
Spring 2003*

**present**

*approval Feb 2001:  
Integr Sci program:  
MPHEC*

*proposal developed  
mid-1990's: UCCB*

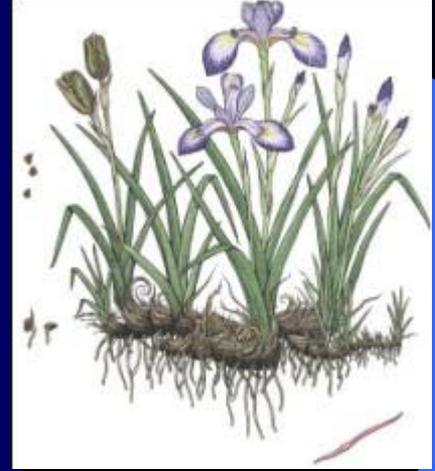
*proposal submitted  
June 1997: UCCB*

*awarded Oct 2002:  
Can Res Chair  
[Jan 2003]*

*proposal approved  
June 1999: UCCB*

*proposal submitted  
June 1999: MPHEC*

Artist Basma Kavanagh



**time line**

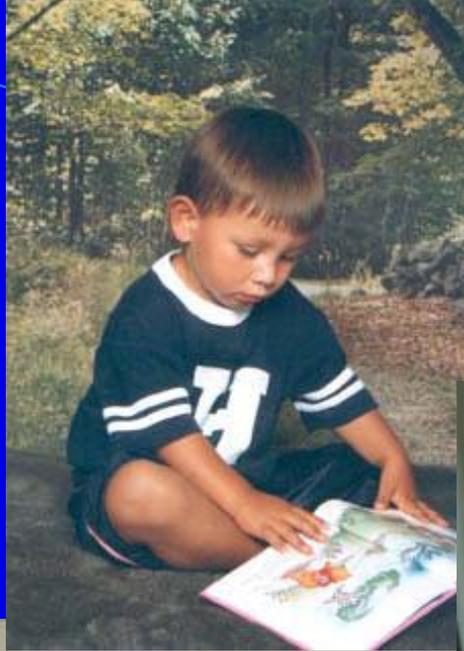
**Integrative Science**



# Why?



# Why?



living knowledge

... AK: yes

... WSK education:  
more "book-based"

spirituality

... AK: yes

... WSK: "no"



AK

#1

Challenges?

disciplinary

... AK: no

... WSK: yes

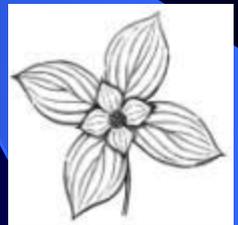
students ...  
more familiar  
with computers  
than nature



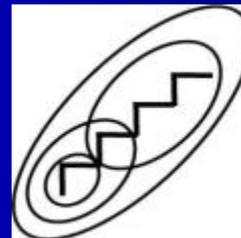
WSK



# How?



Artist Basma Kavanagh



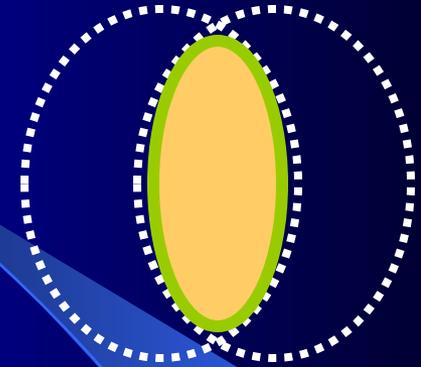
common ground

**Mother  
Earth**



**What?**

**common ground**



**PATTERN**

**PATTERN RECOGNITION**

**Both are based on observations of the environment.**

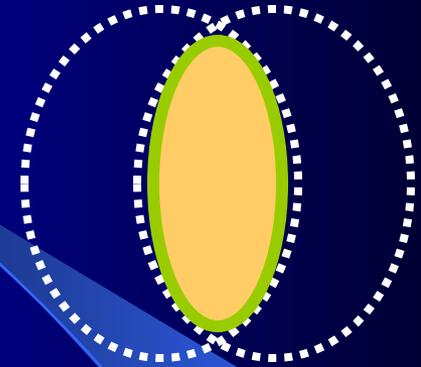
**Both result from the same intellectual process of creating order out of disorder.**

Mother  
Earth



What?

common ground



PATTERN

PATTERN RECOGNITION

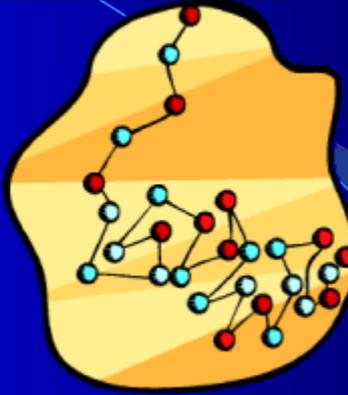
Both are based on observations of the  
environment

Both result from the same intellectual  
process of creating order / harmony er.



Mother Earth

# PATTERNS



common ground  
**PATTERN RECOGNITION**

2-legged creature  
"human"





Mother  
Earth

**PATTERNS**

recognize / make / break  
express / use / transform



Mother  
Earth

**PATTERNS**

recognize / make / break  
express / use / transform

# “expression smarts” for

# PATTERN



- numbers
- language

recognize / make / break  
**express** / use / transform

- music
- body (e.g. dance)
- art
- other people
- self
- naturalist

- spiritual

expression  
tied to  
cultural  
value  
&  
use



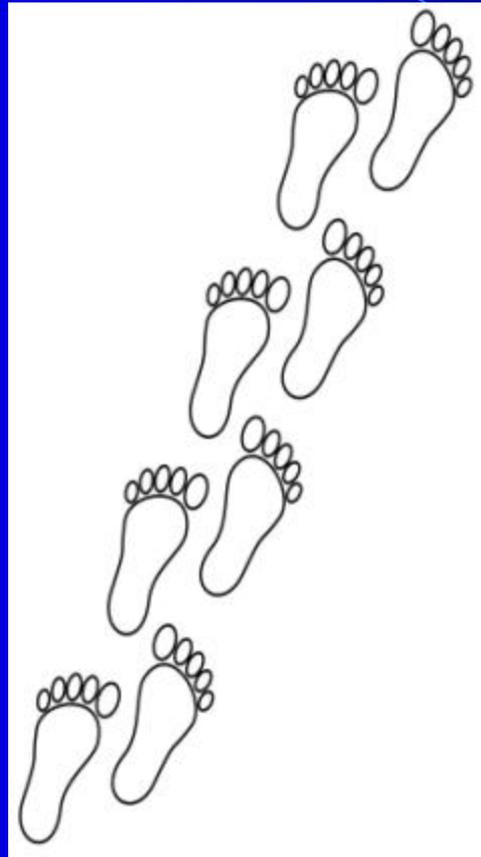
# PATTERN

conceptual framework

natural

ideal

abstract



Mother Earth

recognize / make / break  
express / use / transform

artist  
Basma  
Kavanagh

expression tied to  
cultural value & use



abstract pattern



ideal pattern



Mother  
Earth

**PATTERN**

natural pattern



# VALUE & USE ..... LIVING EARTH

respectful & participatory  
interconnectedness

masterful  
prediction & control

all my relations **pattern**

mathematical **pattern**

expression tied to  
cultural value & use

abstract **pattern**

idea **pattern**

Mother  
Earth  
**PATTERN**

natural **pattern**

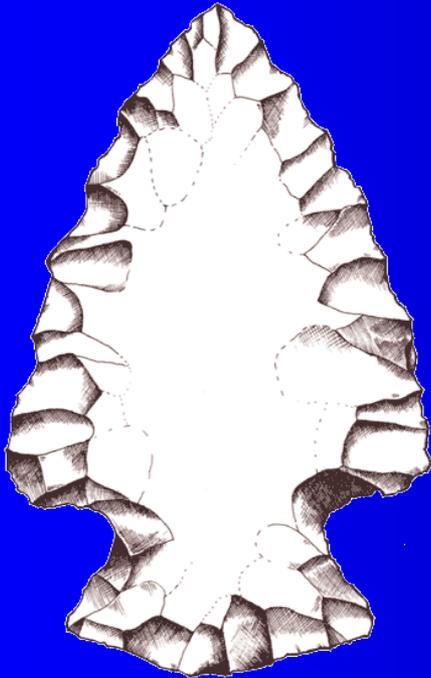






# Aboriginal Knowledge

respectful  
&  
participatory  
interconnectiveness





respectful & participatory interconnectiveness

*Medicine Wheel* ... based on layered pattern:

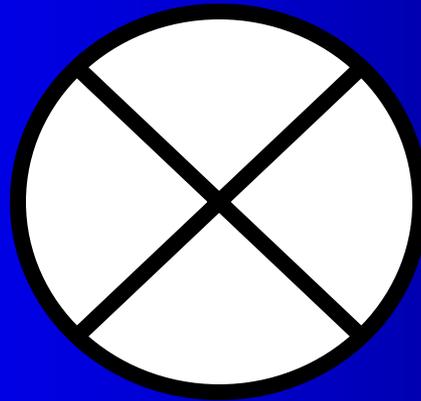
natural



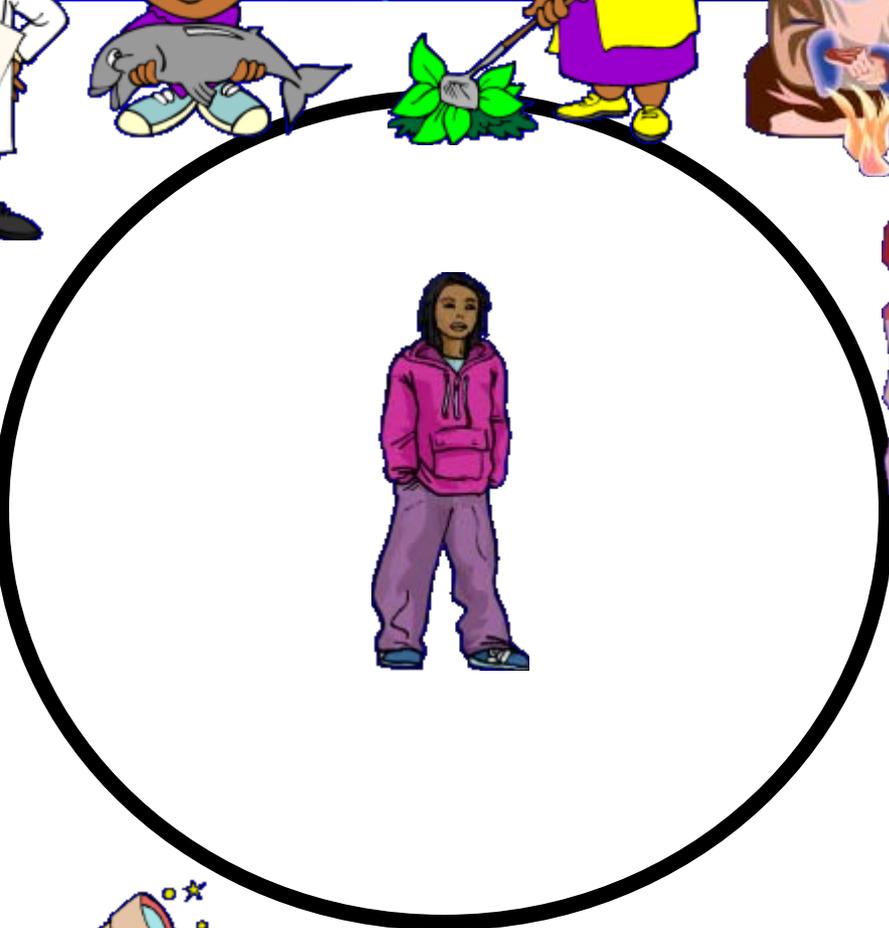
ideal



abstract



**PATTERN**

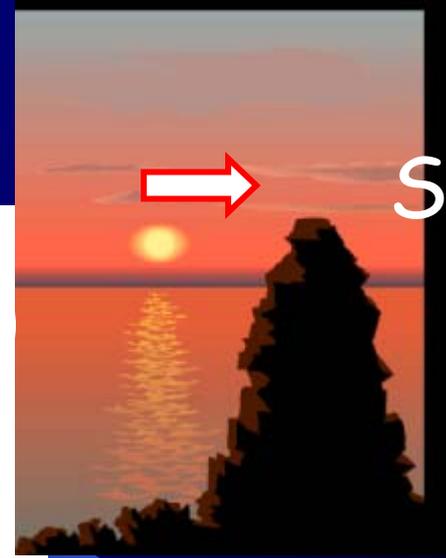
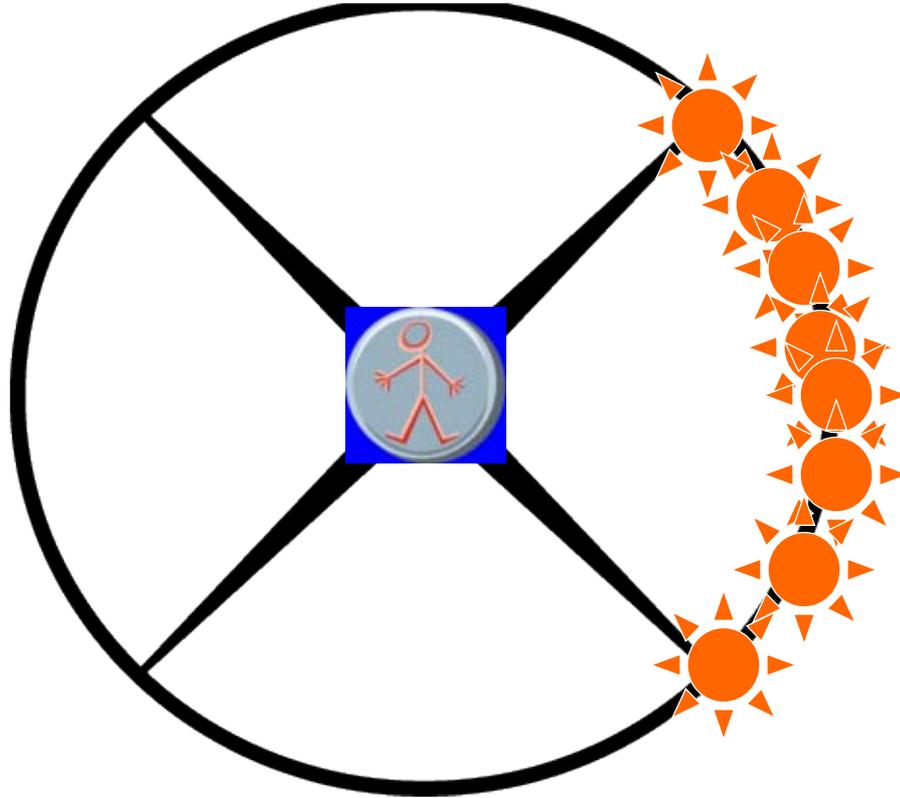


SCIENCE

# sun: natural pattern ... 1 year

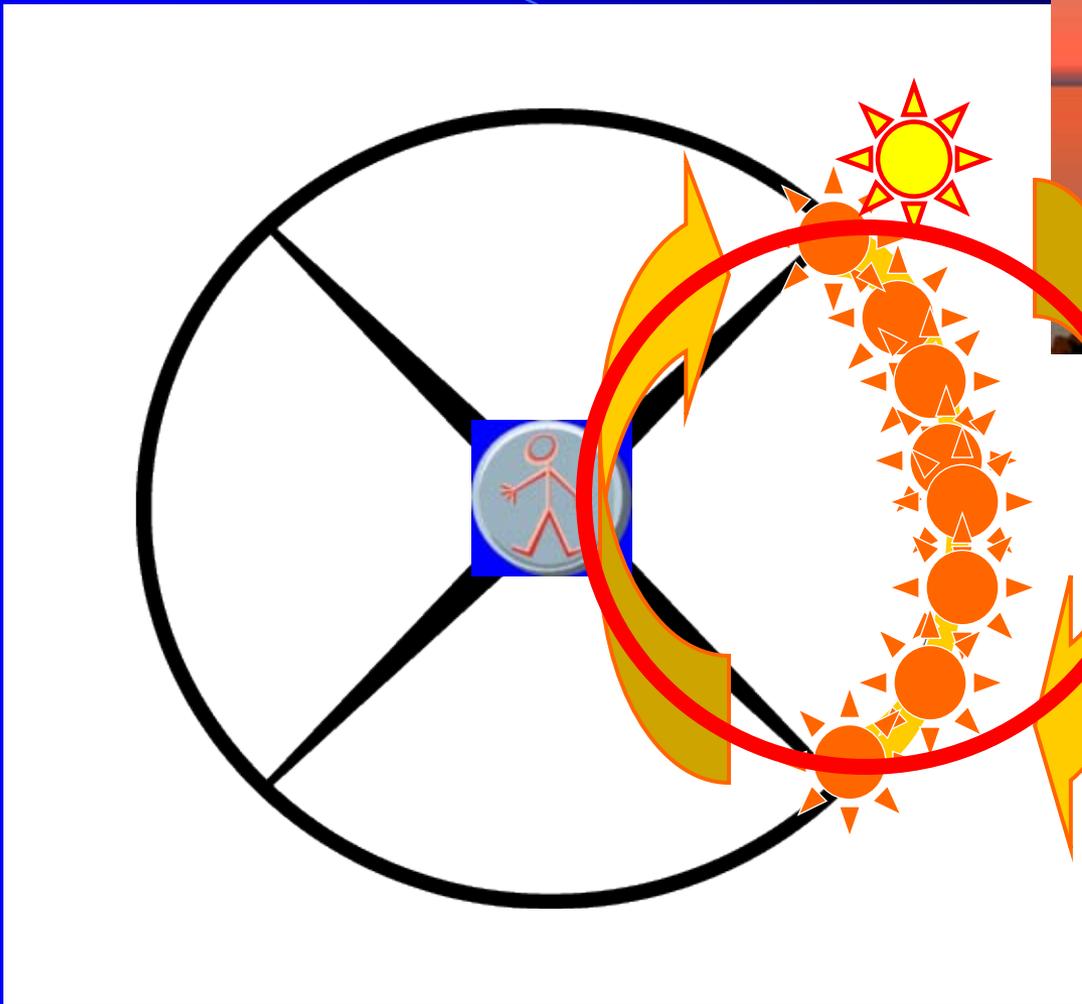
summer solstice (June 21)

National Aboriginal Day



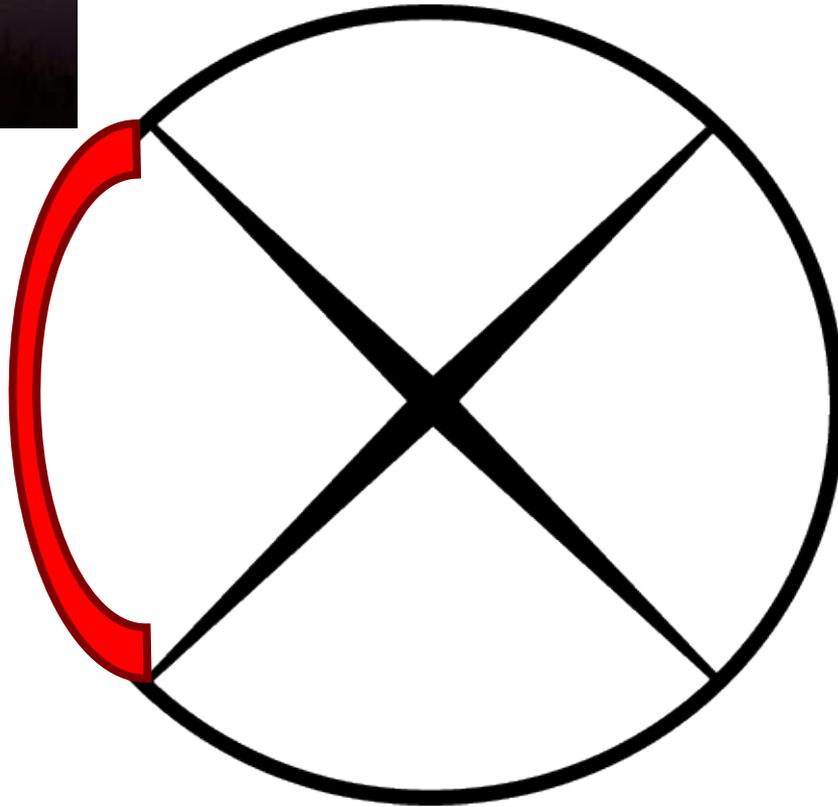
S

N



N

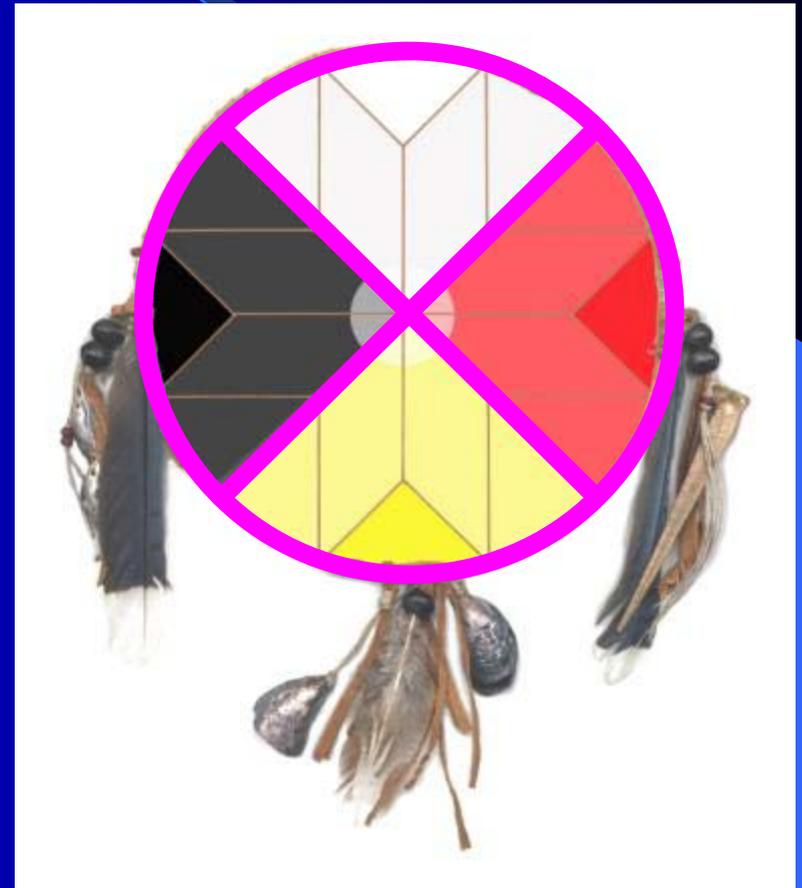
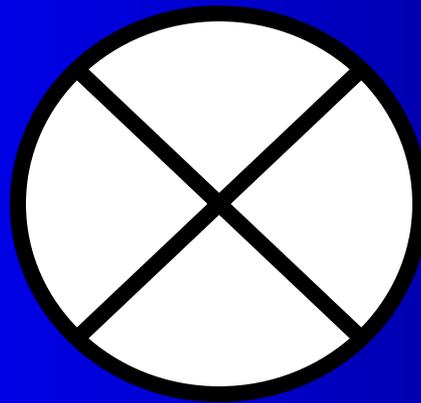






respectful & participatory interconnectiveness

*Medicine Wheel* ... based on layered pattern:  
natural  $\diamond$  ideal  $\diamond$  abstract

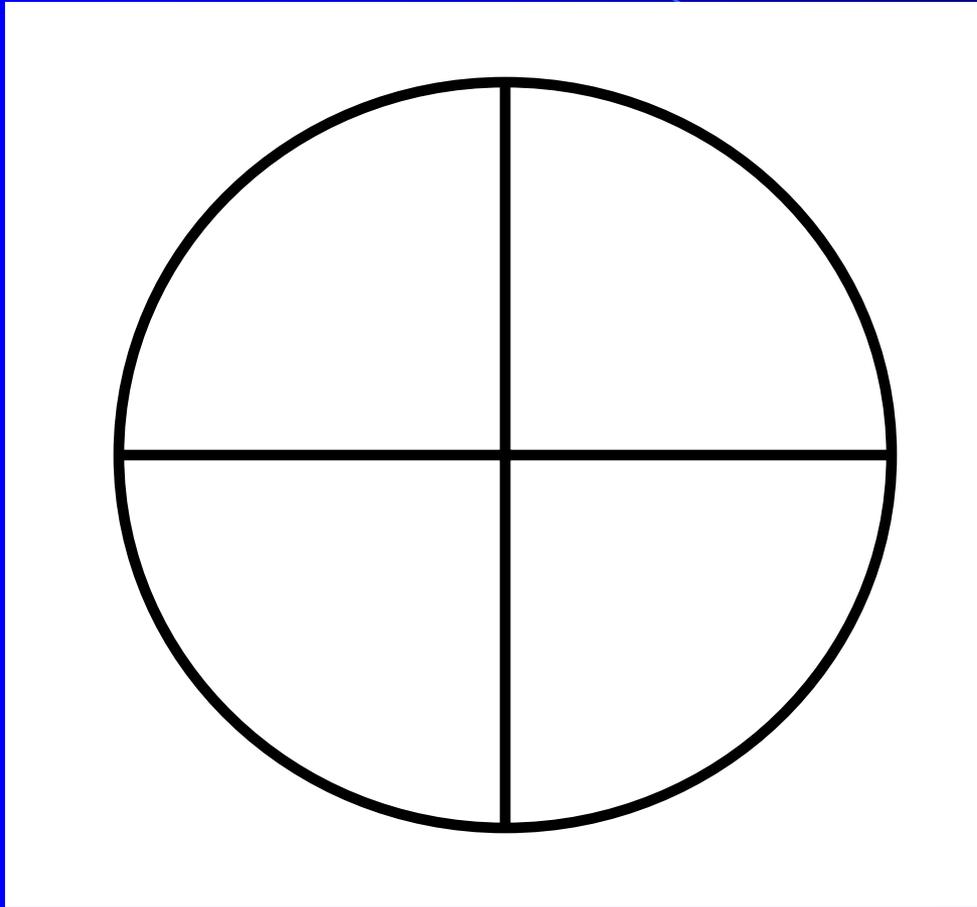


**PATTERN**

north



west



east

south

natural

← ADD

ideal

← ADD

abstract

ideal

natural

(layering)

# Medicine Wheel Representations - many layers -

cognitive



physical



spiritual



emotional

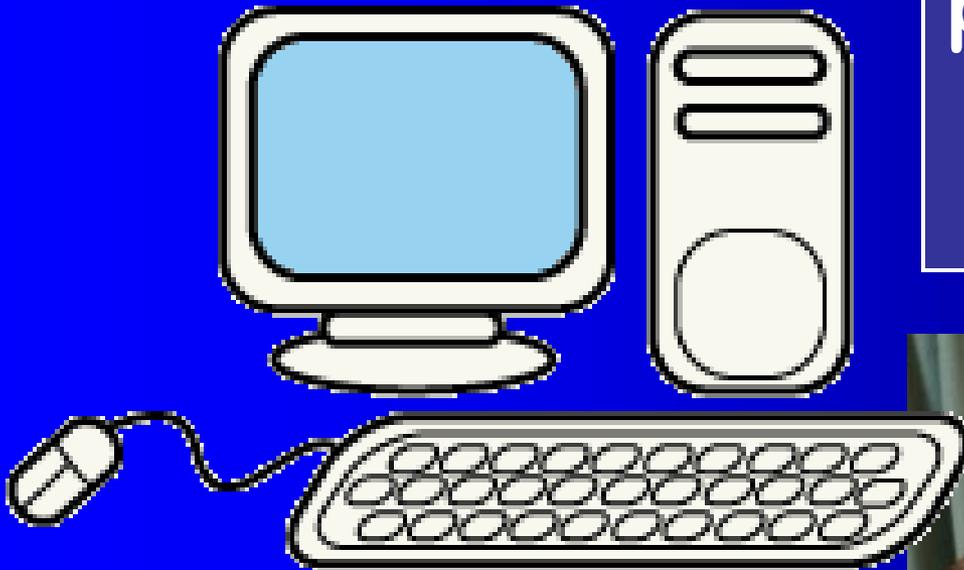
**PATTERN**

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

work by Dina Bernard,  
summer research student

# Western Science Knowledge

masterful  
prediction  
&  
control





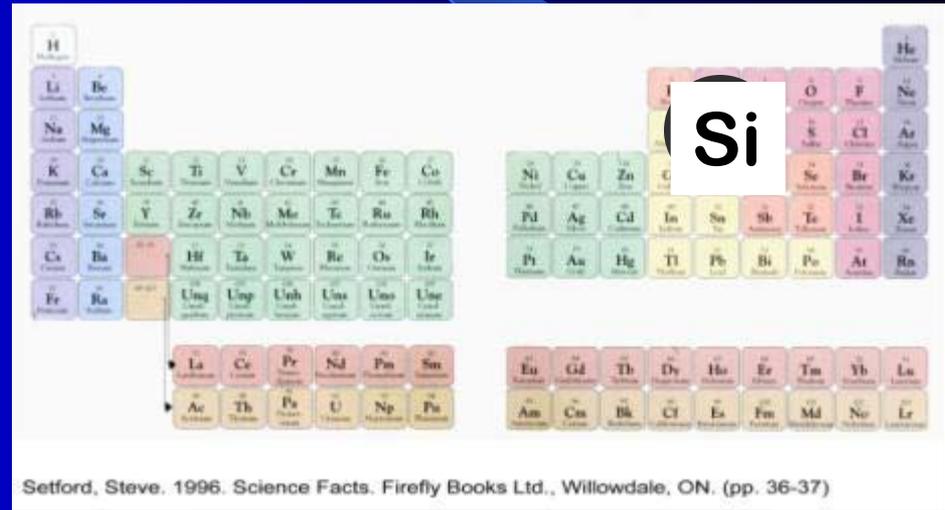
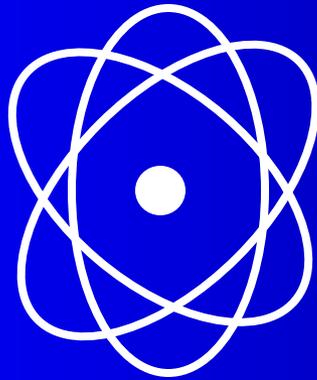
# masterful prediction & control

*Periodic Table* ... based on layered pattern:

natural

ideal

abstract



# PATTERN

# 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 organisms<sup>1,2</sup>. 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 silica<sup>3,4</sup>. *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 spicules<sup>5</sup> 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  $\mu\text{m}$  in diameter; their native cross-section is homogeneous and they have no structural boundaries. Under stress or etching, the spicules reveal a characteristic layered morphology<sup>6</sup> and cross-sectional variations in composition that appear as three distinct regions: a pure silica core of about 2  $\mu\text{m}$  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 profiling<sup>7</sup> 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

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<sup>8,9</sup>. Another superior feature of the spicules is their formation under ambient conditions, a process that is regulated by organic molecules<sup>10,11</sup>. 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.

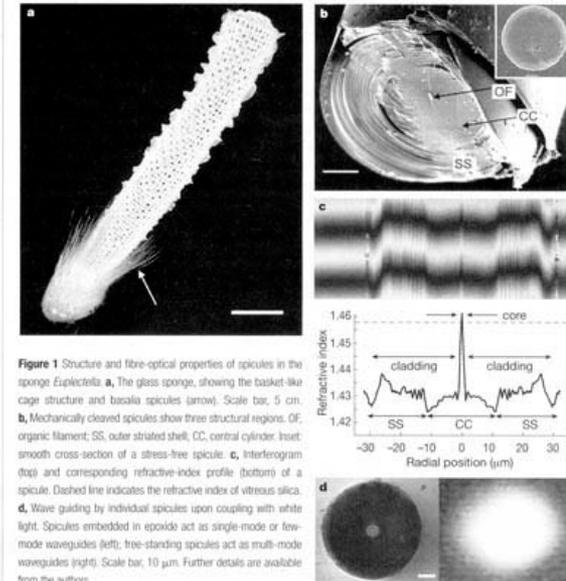
Our results suggest the intriguing possibility that the spicules of *Euplectella*, beyond structural anchorage support, could also provide a highly effective fibre-optical network, which may be useful in distributing light in its deep-sea environment. This illuminating sponge should also shed light on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

Vikram C. Sundar\*, Andrew D. Yablon†, John L. Grazul‡, Micha Ilan‡, Joanna Aizenberg\*

\*Bell Laboratories/Lucent Technologies, Murray Hill, New Jersey 07974, USA  
e-mail: jaitzenberg@lucent.com

†OFS, Murray Hill, New Jersey 07974, USA

‡Department of Zoology, Tel Aviv University, Tel Aviv 69978, Israel



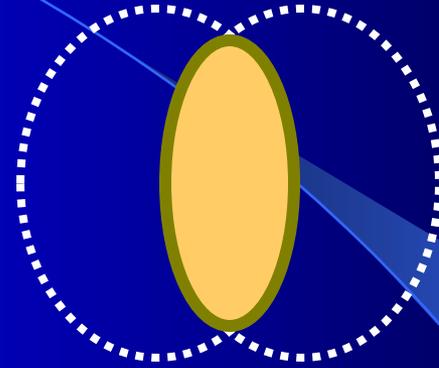
**Figure 1** Structure and fibre-optical properties of spicules in the sponge *Euplectella*. **a**, The glass sponge, showing the basket-like cage structure and basalia spicules (arrow). Scale bar, 5 cm. **b**, Mechanically cleaved spicules show three structural regions. OF, organic filament; SS, outer striated shell; CC, central cylinder. Inset: smooth cross-section of a stress-free spicule. **c**, Interferogram (top) 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 (left); free-standing spicules act as multi-mode waveguides (right). Scale bar, 10  $\mu\text{m}$ . Further details are available from the authors.



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

**PATTERN**

Mother  
Earth



common ground

## PATTERN RECOGNITION

example ...

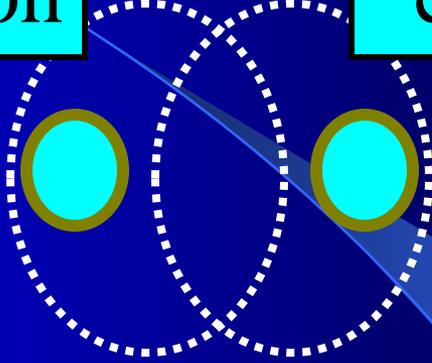
in the **patterns** of the animals  
... lessons for humans

Mother Earth



respectful participation

masterful control

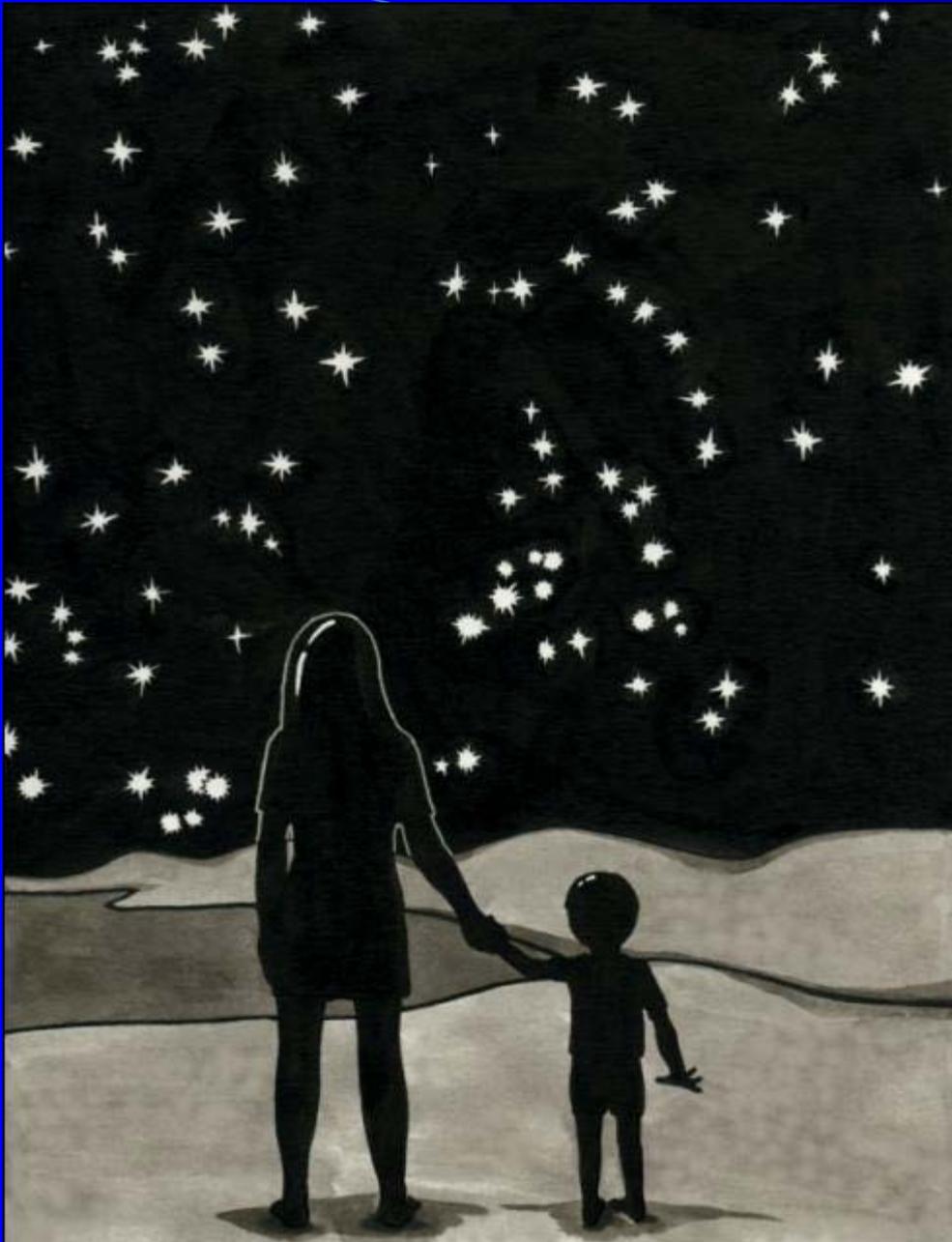


divergence

VALUE - USE

example ...

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



awareness

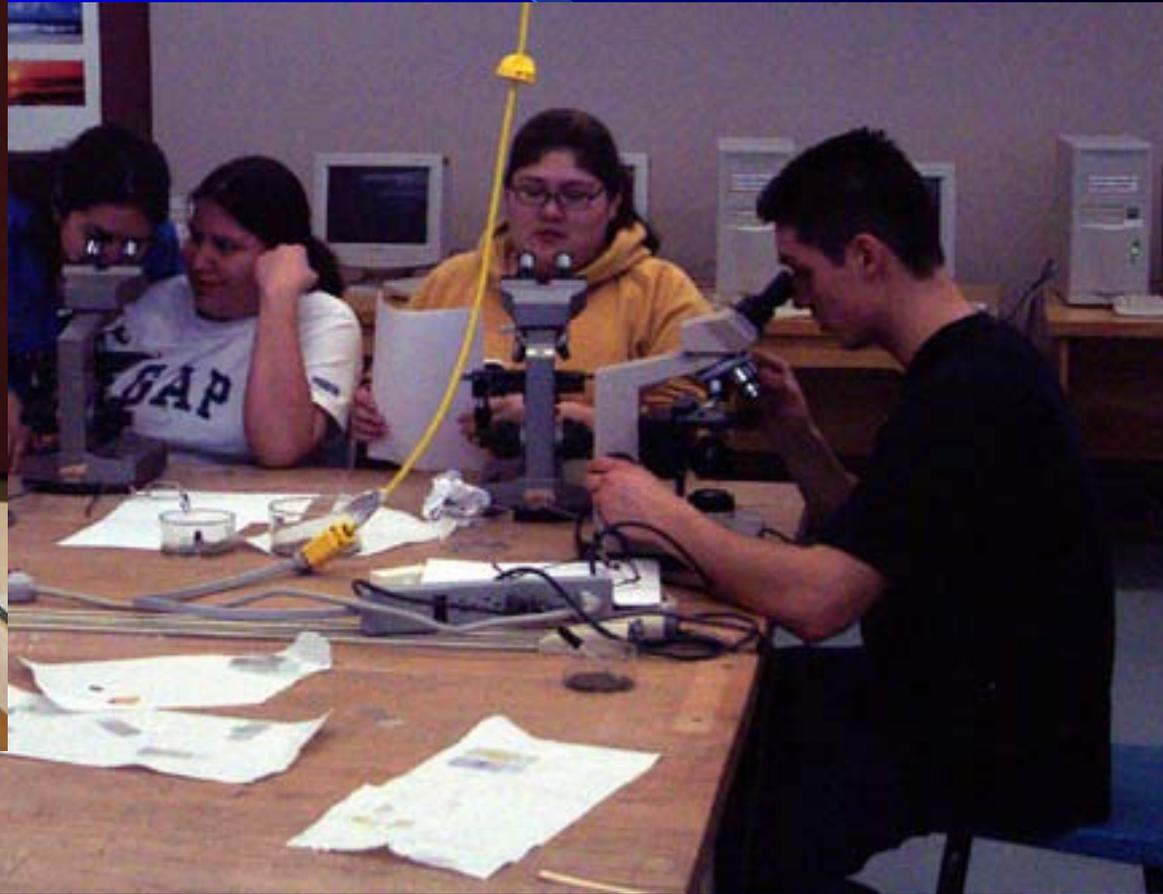
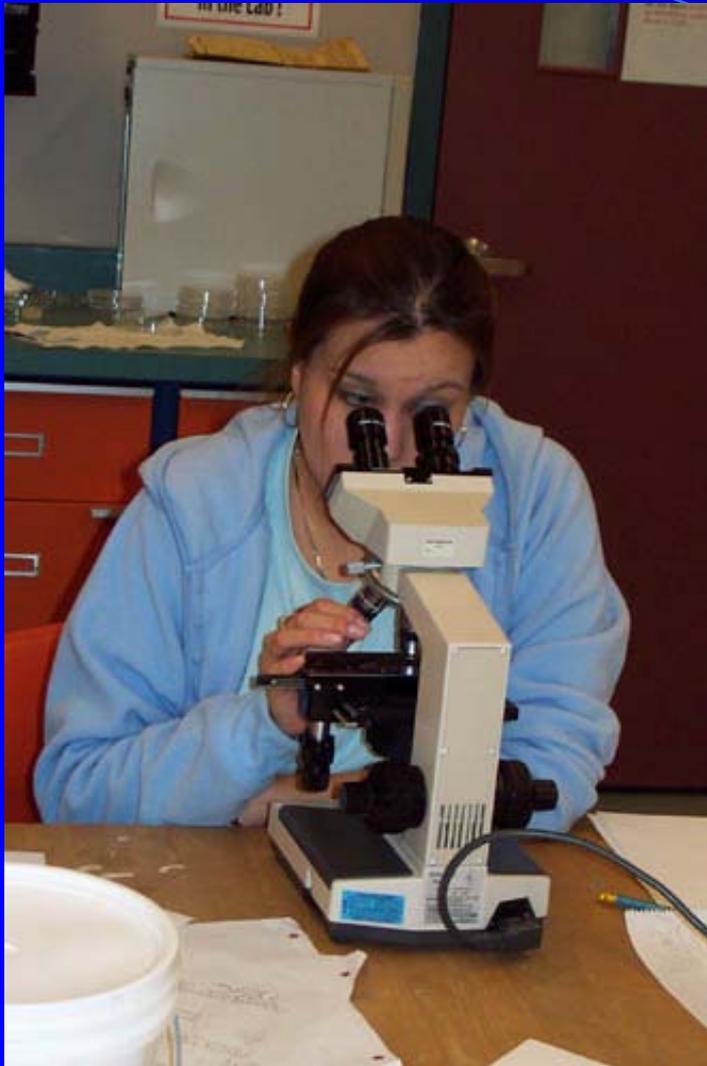
patterns

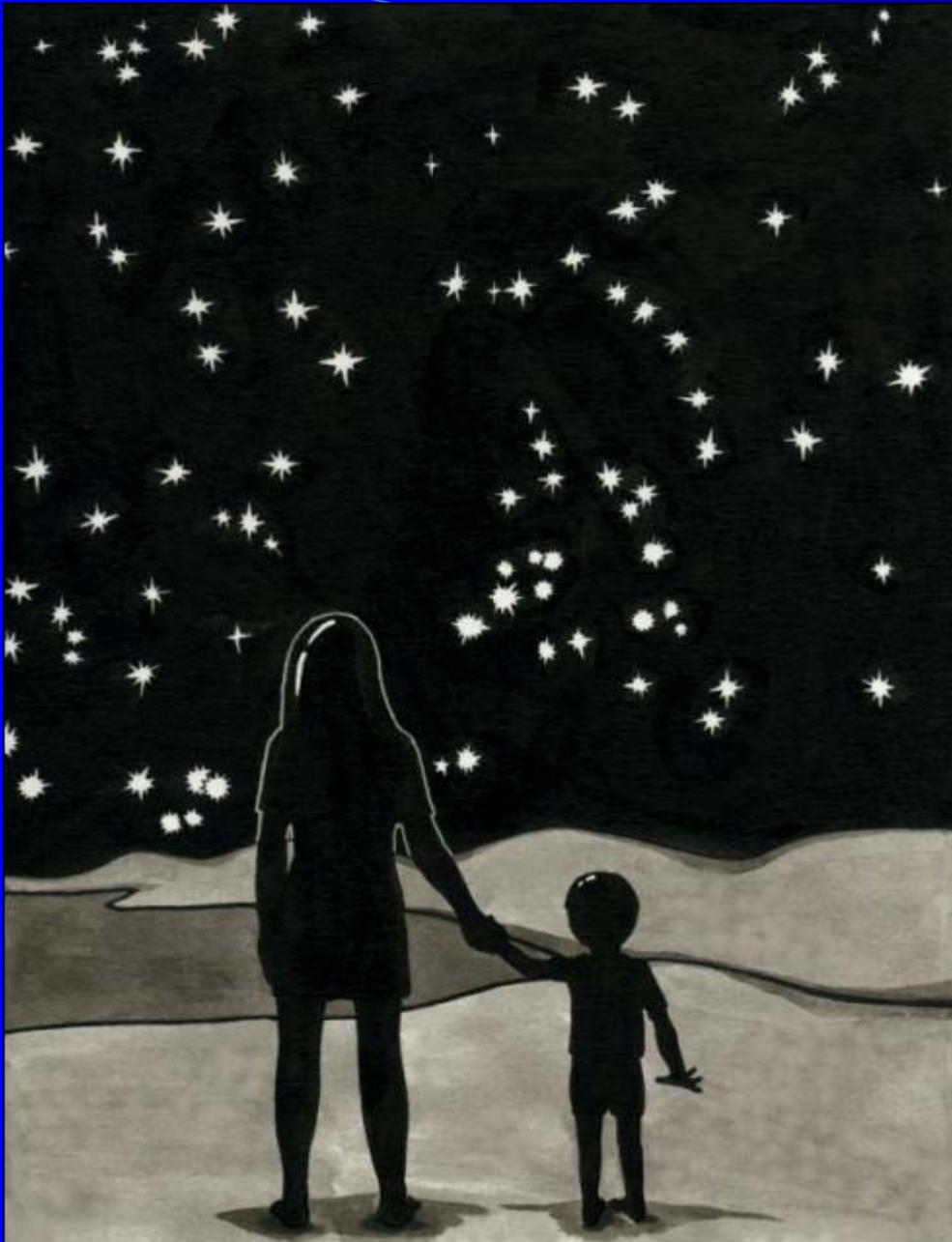
Integrative  
Science

artist  
Basma  
Kavanagh









awareness

patterns

metaphors

Integrative  
Science

artist  
Basma  
Kavanagh

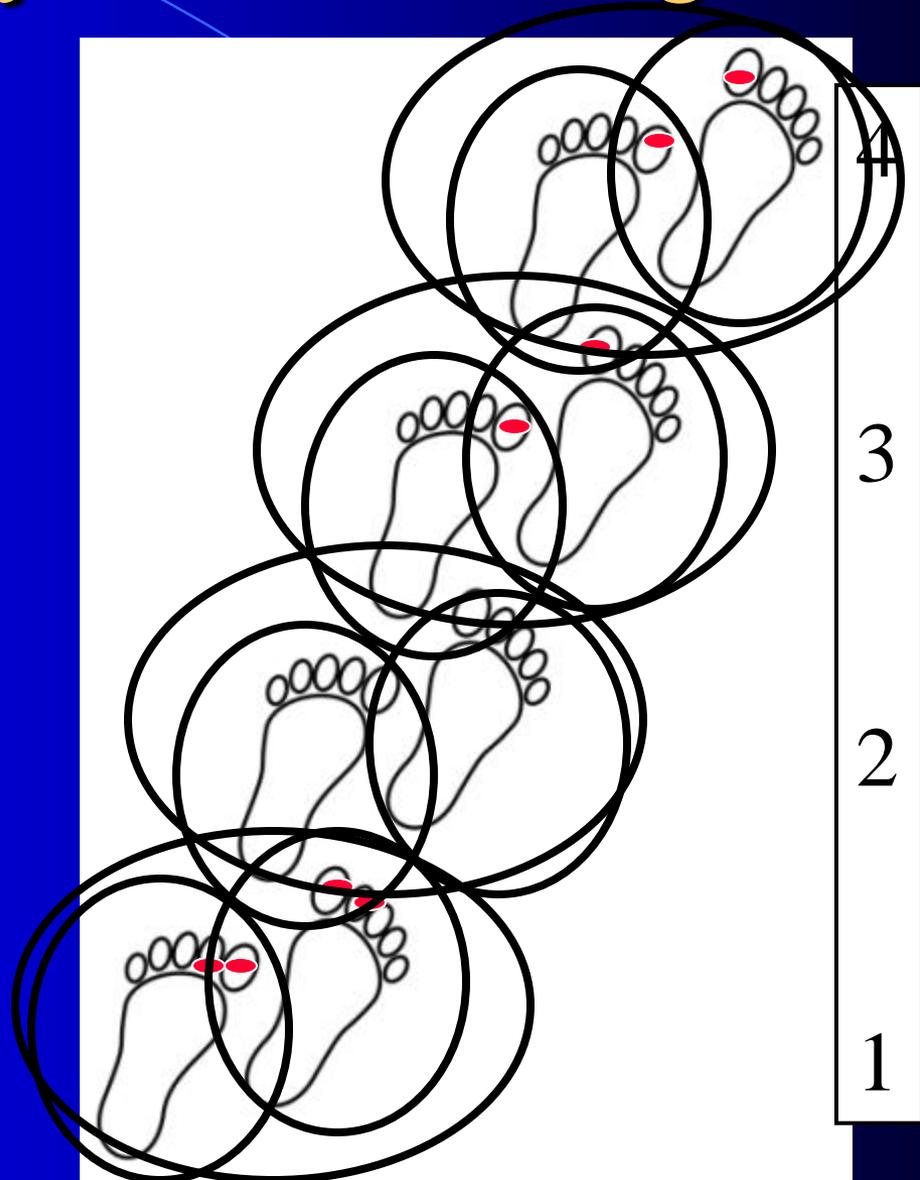
# 4 yr university science degree

MSIT courses



Integrative Science

**PATTERN**



Artist Arlene (Dozay) Christmas



Integrative  
Science

university  
science



Artist Arlene (Dozay) Christmas



Integrative  
Science

university  
science

**CHALLENGES**

students ...  
more familiar  
with computers  
than nature

spirituality

disciplinary  
fragmentation

living knowledge



Artist  
Basma Kavanagh



artist  
Basma  
Kavanagh

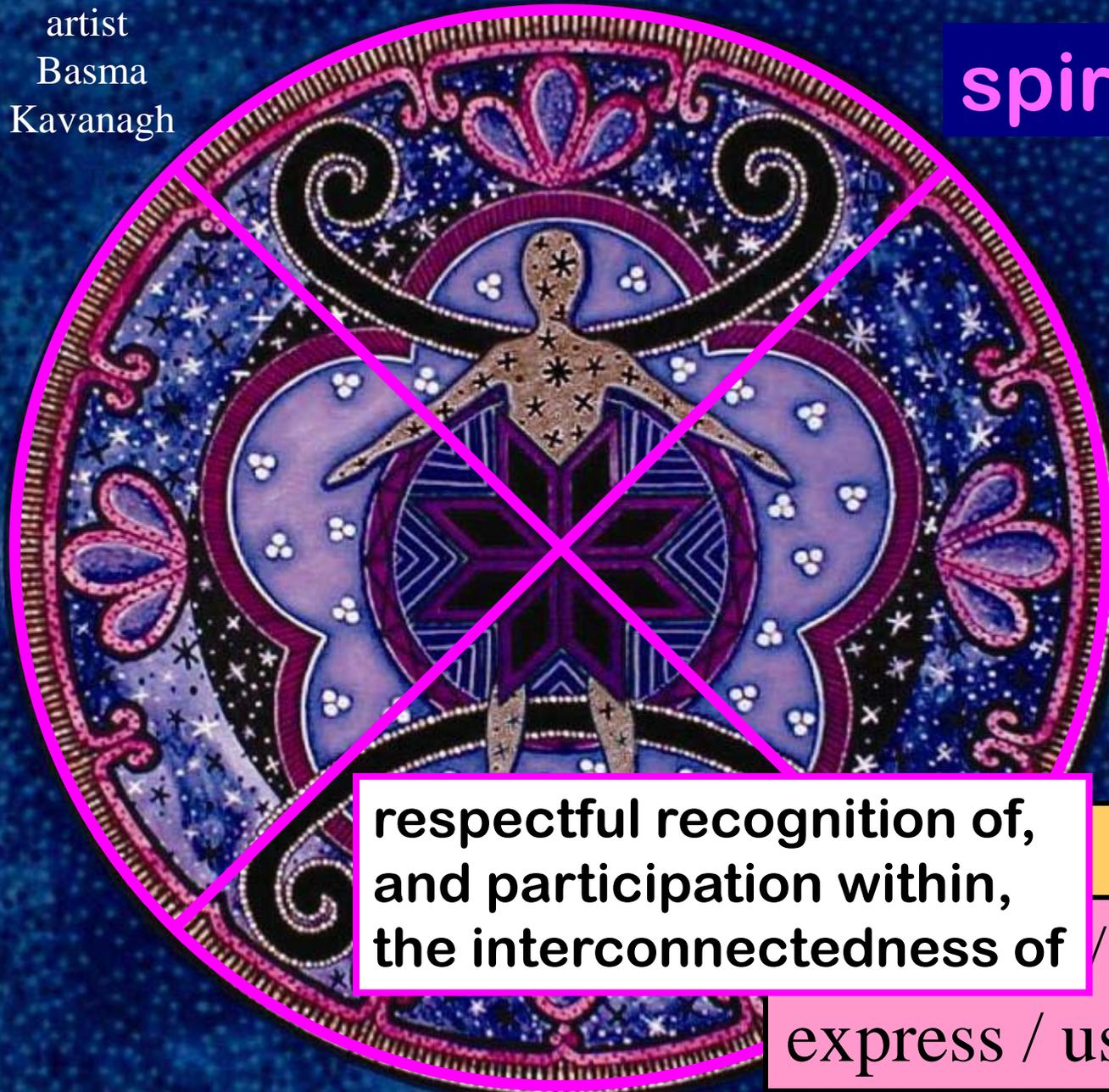


## PATTERN

recognize / make / break  
express / use / transform

artist  
Basma  
Kavanagh

spirituality



respectful recognition of,  
and participation within,  
the interconnectedness of

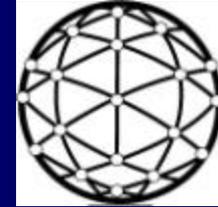
**PATTERN**

/ make / break

express / use / transform

Artist Basma Kavanagh

spirituality

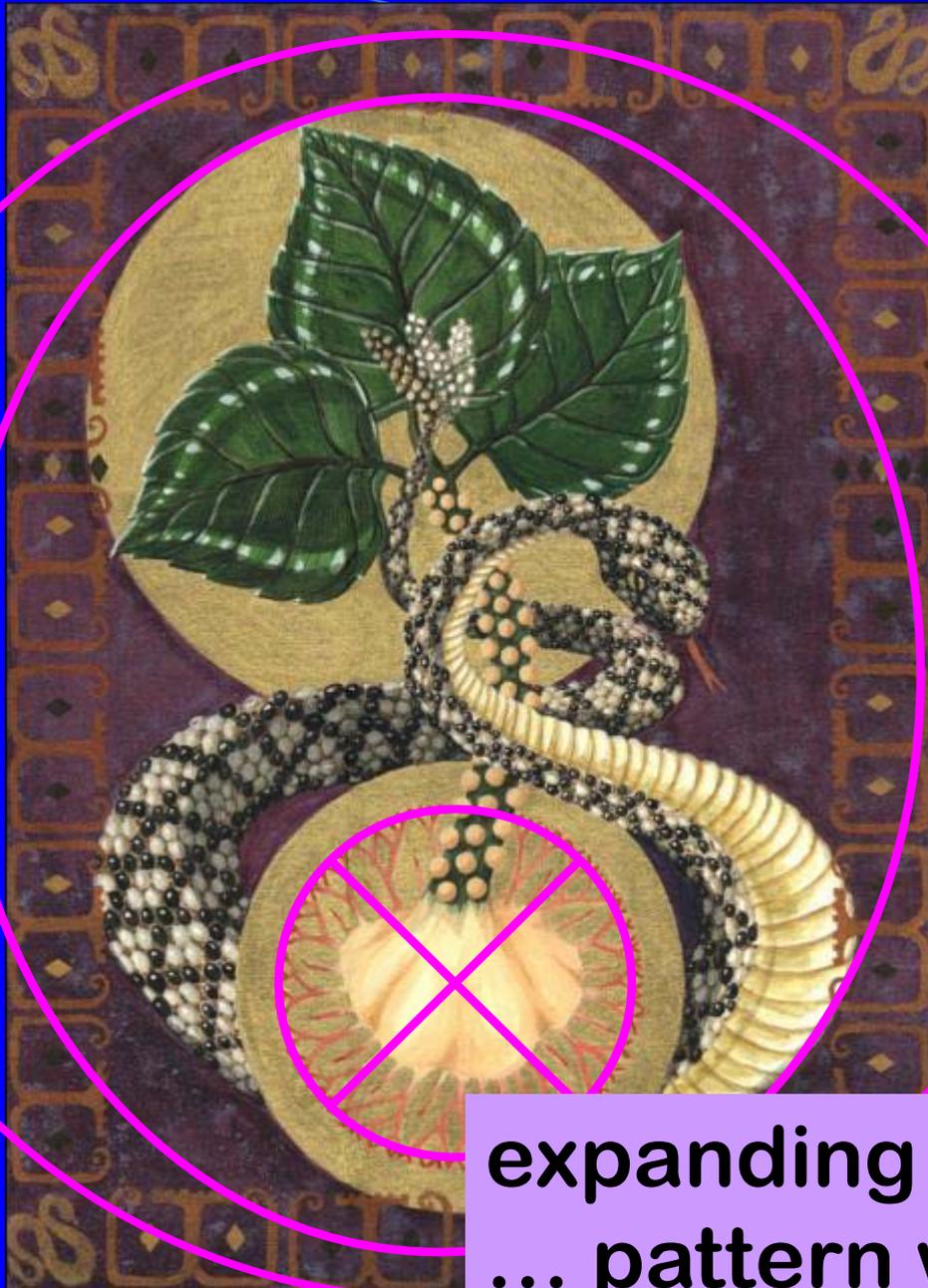


**PATTERN**

- TRANSFORM
- WEAVE

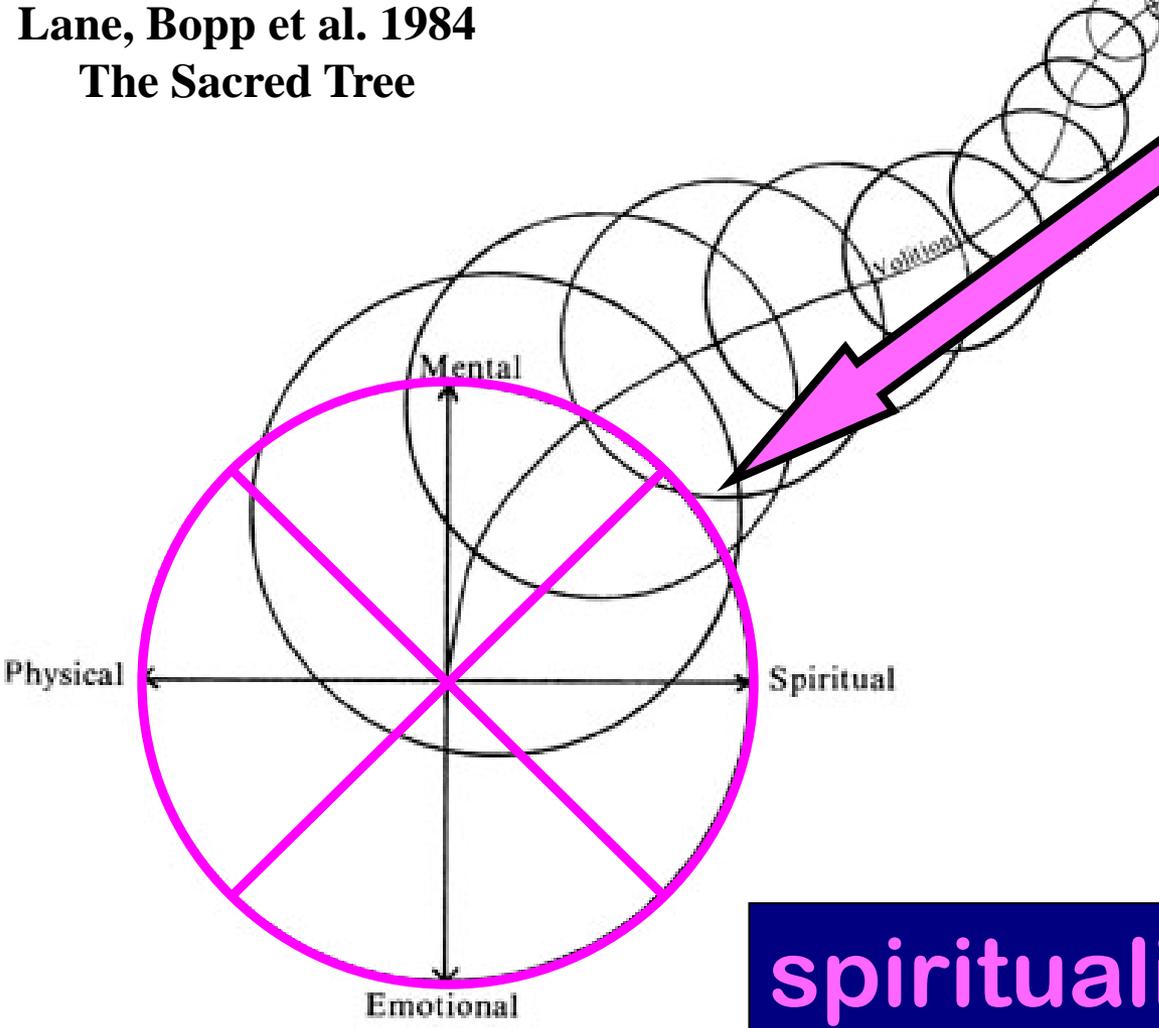
inner – outer – inner – outer

**expanding sense of wholeness  
... pattern within pattern**



*image from:*  
**Lane, Bopp et al. 1984**  
**The Sacred Tree**

Vision 



**spirituality**

**expanding sense of wholeness**  
**... pattern within pattern**

Artist Basma Kavanagh



respectful & participatory  
interconnectedness

all my relations pattern

weave **PATTERN**  
... to create new **PATTERN**

expanding sense of wholeness  
... pattern within pattern

unknown

FEAR



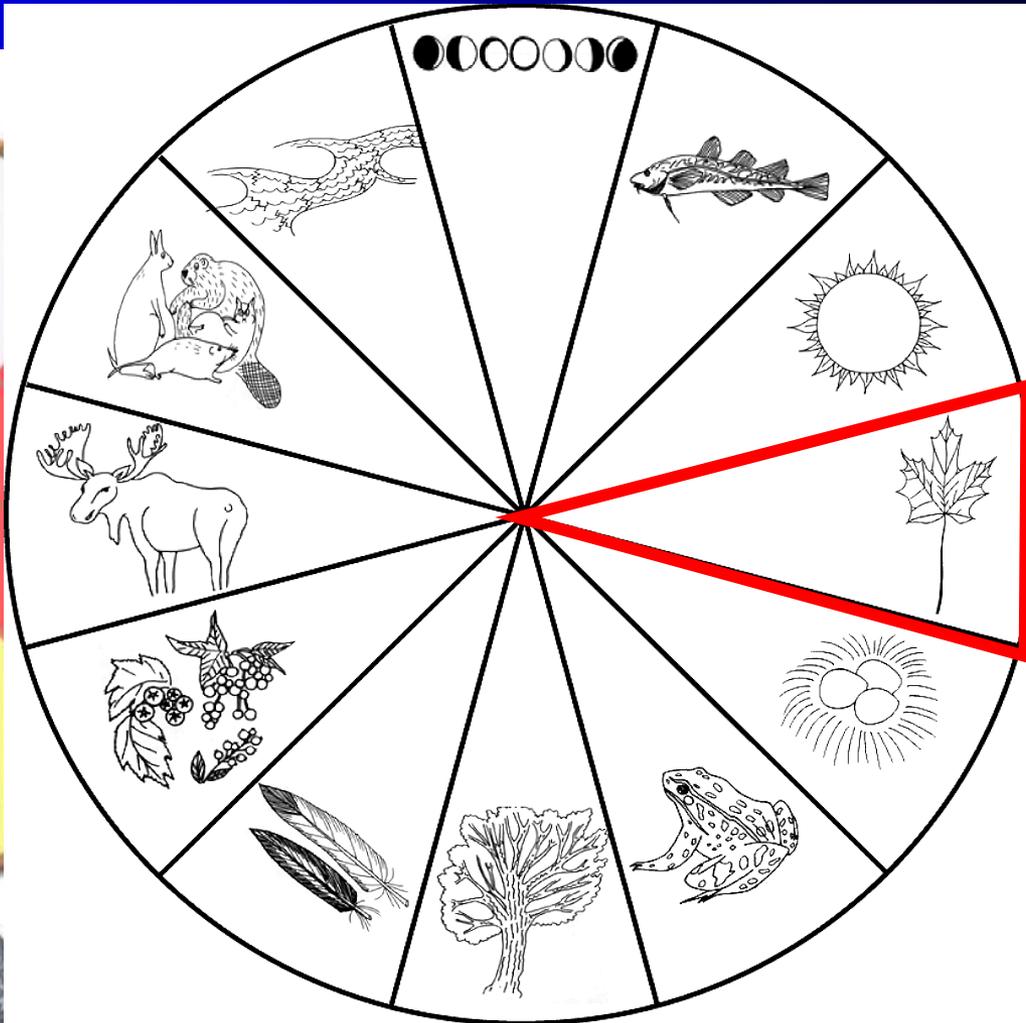
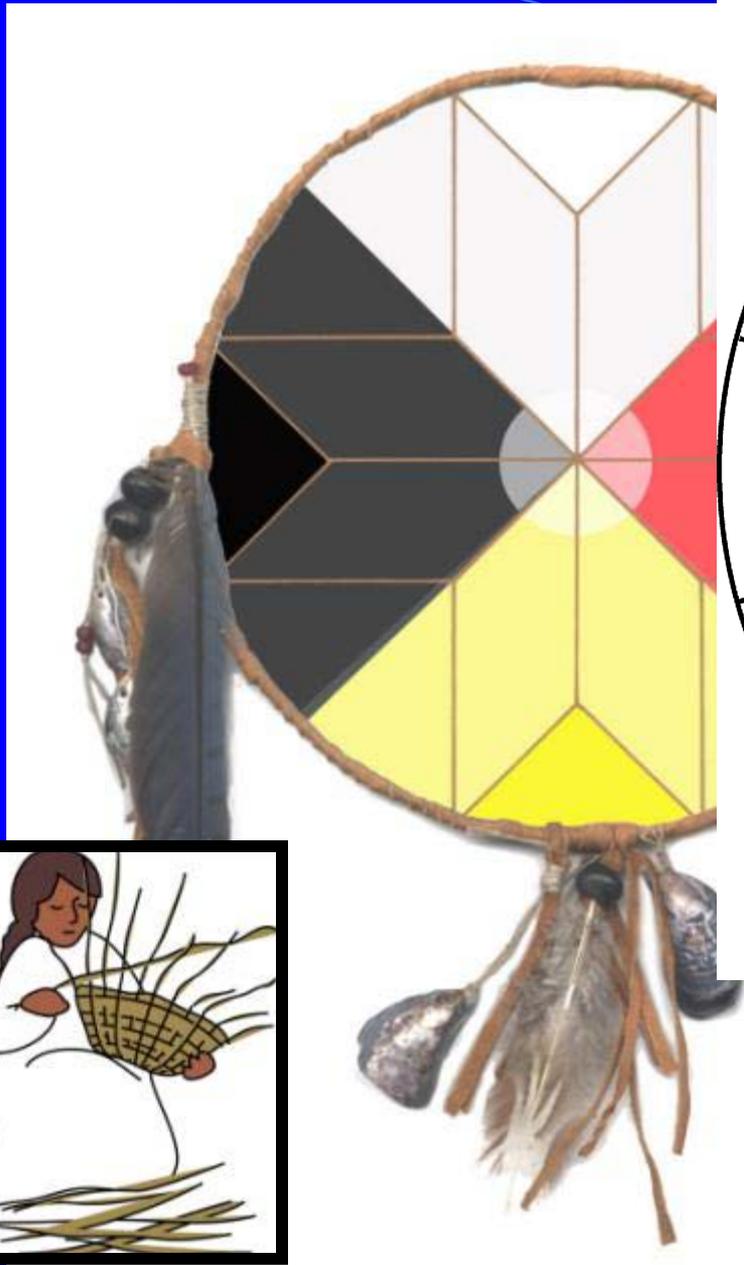
known



**Mother Earth**  
... especially, patterns  
of the animals



**“must become PATTERNable”**



**Mi'kmaq language**  
moon months  
= natural pattern



# WEAVING

Artist Basma Kavanagh

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



Integrative Science



Artist Basma Kavanagh

# UN-WEAVING

- data collection
- analysis
- interpretation
- prediction
- control



Integrative Science



**cognitive**

knowing

**physical**

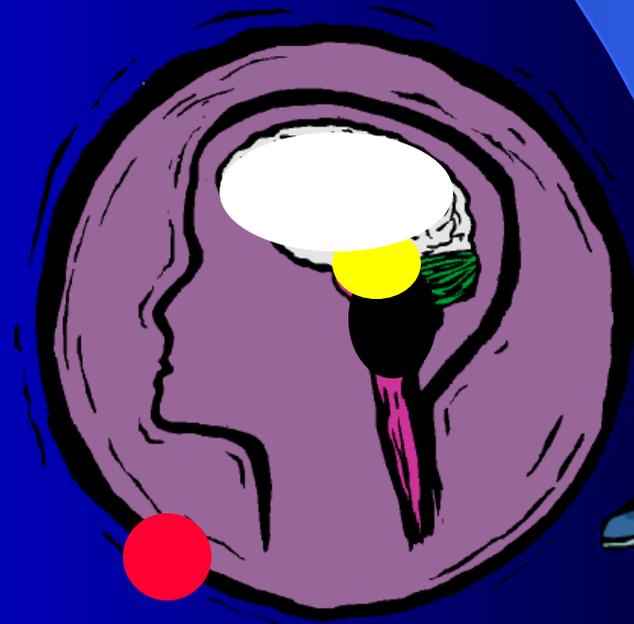
doing

**spiritual**

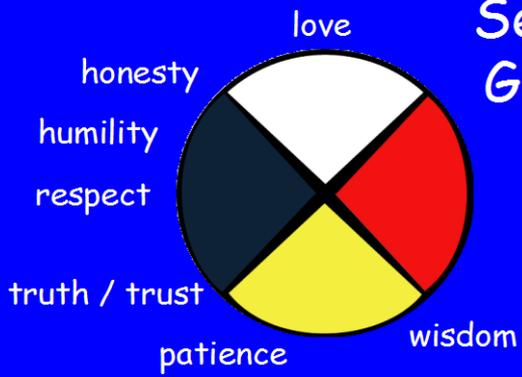
loving valuing

**emotional**

feeling



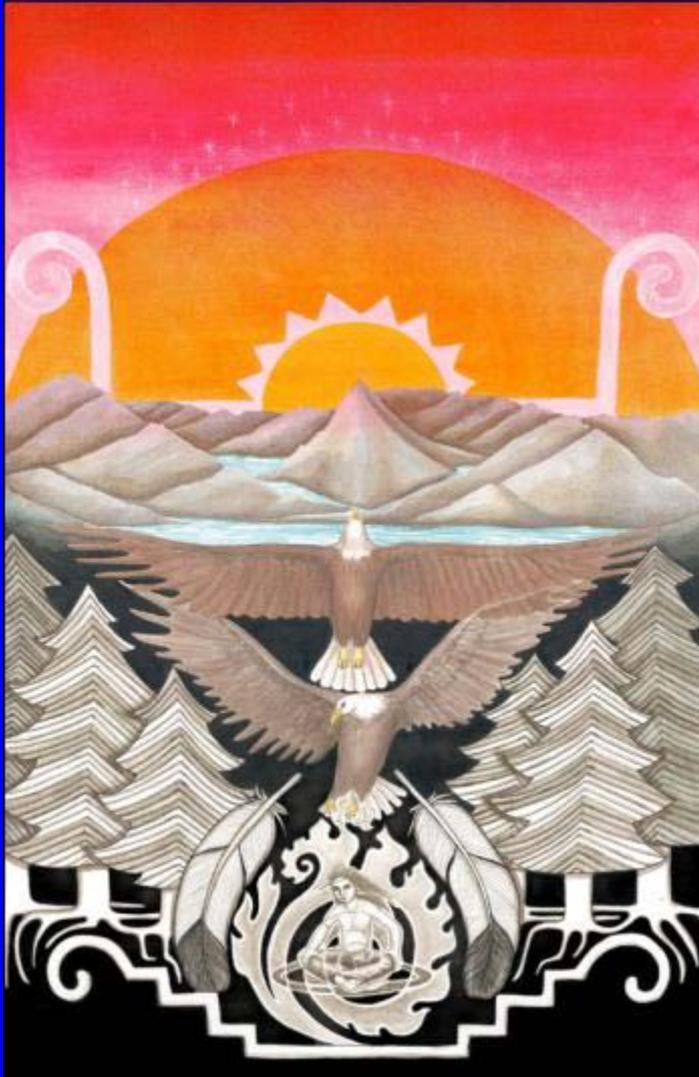
# Seven Gifts



## STUDENTS EXAMINING BRAINS



# Integrative Science ... relevance:



Artist Basma Kavanagh

Community

Resource management

Health

“Sense of ...”

Stewardship/Sustainability

Environmental issues

Ecology

Interpretation

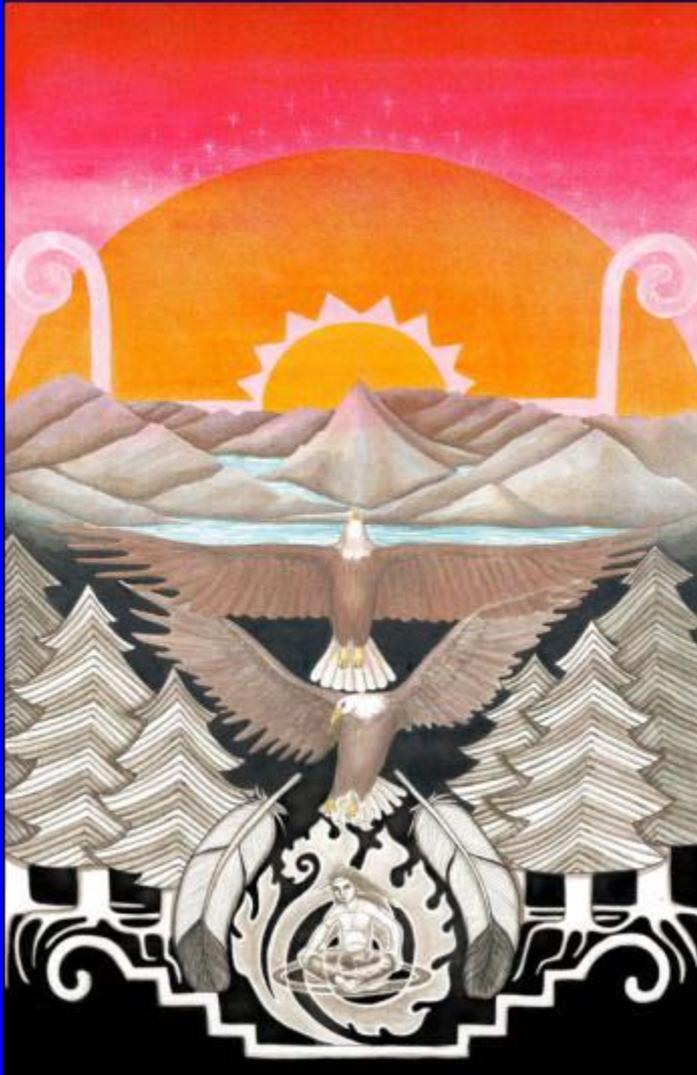
Education

# acknowledgements

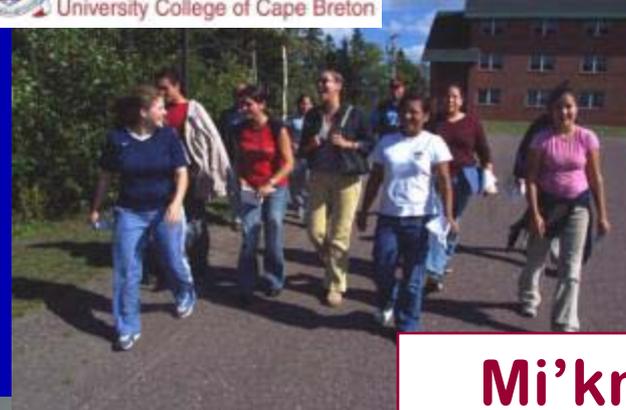


Canada Research  
Chairs

Chaires de recherche  
du Canada



Artist Basma Kavanagh



**Mi'kmaq  
communities**



Artist Basma Kavanagh

Thank you  
Wela'liog

