

Title: Interstellar Voyaging

Date: Dec 03, 2014 07:00 PM

URL: <http://pirsa.org/14120023>

Abstract: <p>Interstellar Voyaging</p>

<p>The discovery of countless exoplanets and new ideas in propulsion physics have resurrected international interest in the ancient concept of humanity traveling far beyond Earth. Such voyages will take place over many generations, requiring careful attention to both biological and cultural change over time. In this talk I will outline the foundations of a biocultural science of long-term space settlement. </p>



Tonight's Public Lecture

Cameron Smith

Interstellar Voyaging:
An Evolutionary Transition

December 3, 2014



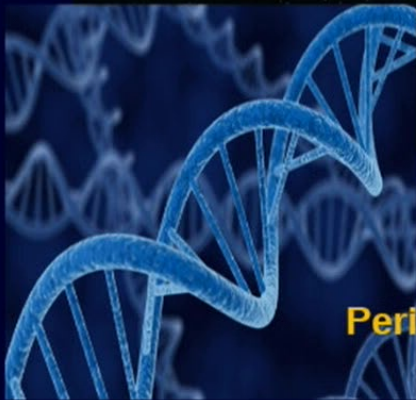
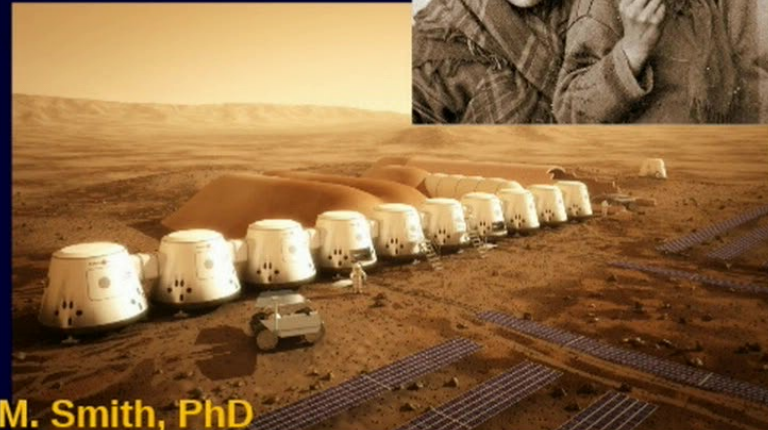
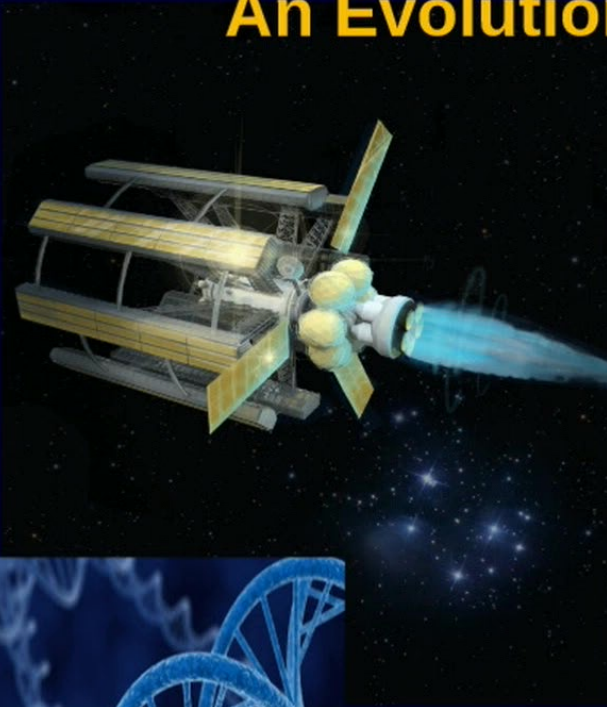
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Interstellar Voyaging: An Evolutionary Transition



Cameron M. Smith, PhD
Dept. of Anthropology
Portland State University
Perimeter Institute for Theoretical Physics
December 2014

Interstellar Voyaging:
An Evolutionary Transition (1)

Premises

NASA's largest goals all have to do with living things:

To Improve Life Here

To Extend life There

To Find Life Beyond



"Nothing in biology makes sense except in the light of evolution."

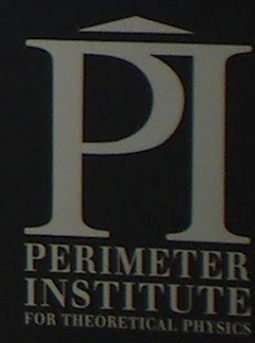
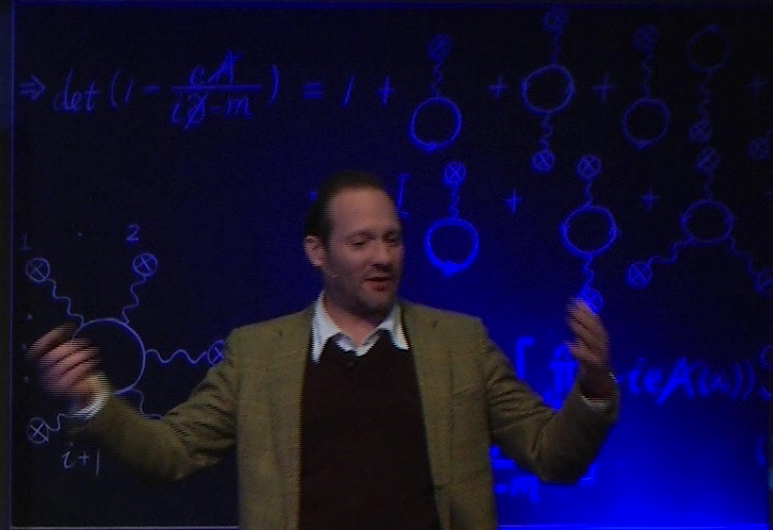
-- T. Dobzhansky, 1973

Many others of course also focusing on space settlement after a generation-long hiatus in interest.

$$\Rightarrow \det \left(1 - \frac{eA}{i\hbar - m} \right) = 1 + \text{circles} + \text{circles} + \text{circles} + \dots$$

$$\frac{\alpha - \lambda}{\lambda + i\epsilon}$$

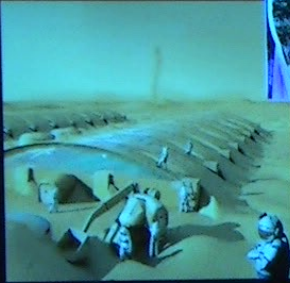
$$[\dots - i e A(\omega)]$$



Interstellar Voyaging:
An Evolutionary Transition (2)

Premises

Space colonization will be a natural continuation of four million years of hominin adaptation.



We require a science of 'Extraterrestrial Adaptation'

$\Rightarrow \det(1 - \frac{eA}{i\partial - m}) = 1 + \text{circles} + \text{circles} + \dots$

$= e^{-1} + \dots$

$= -\frac{1}{\pi} \int \dots$

$= -\dots$

(M)

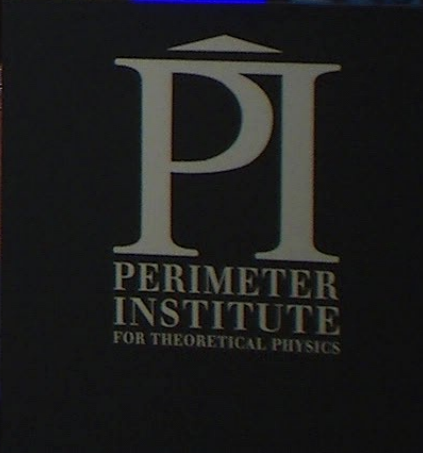
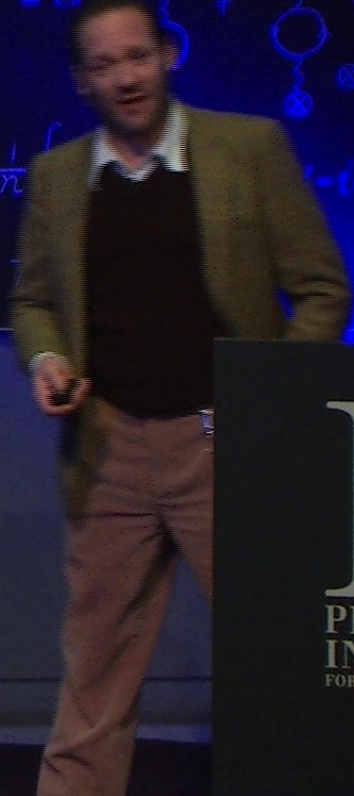
$\sim \gamma$

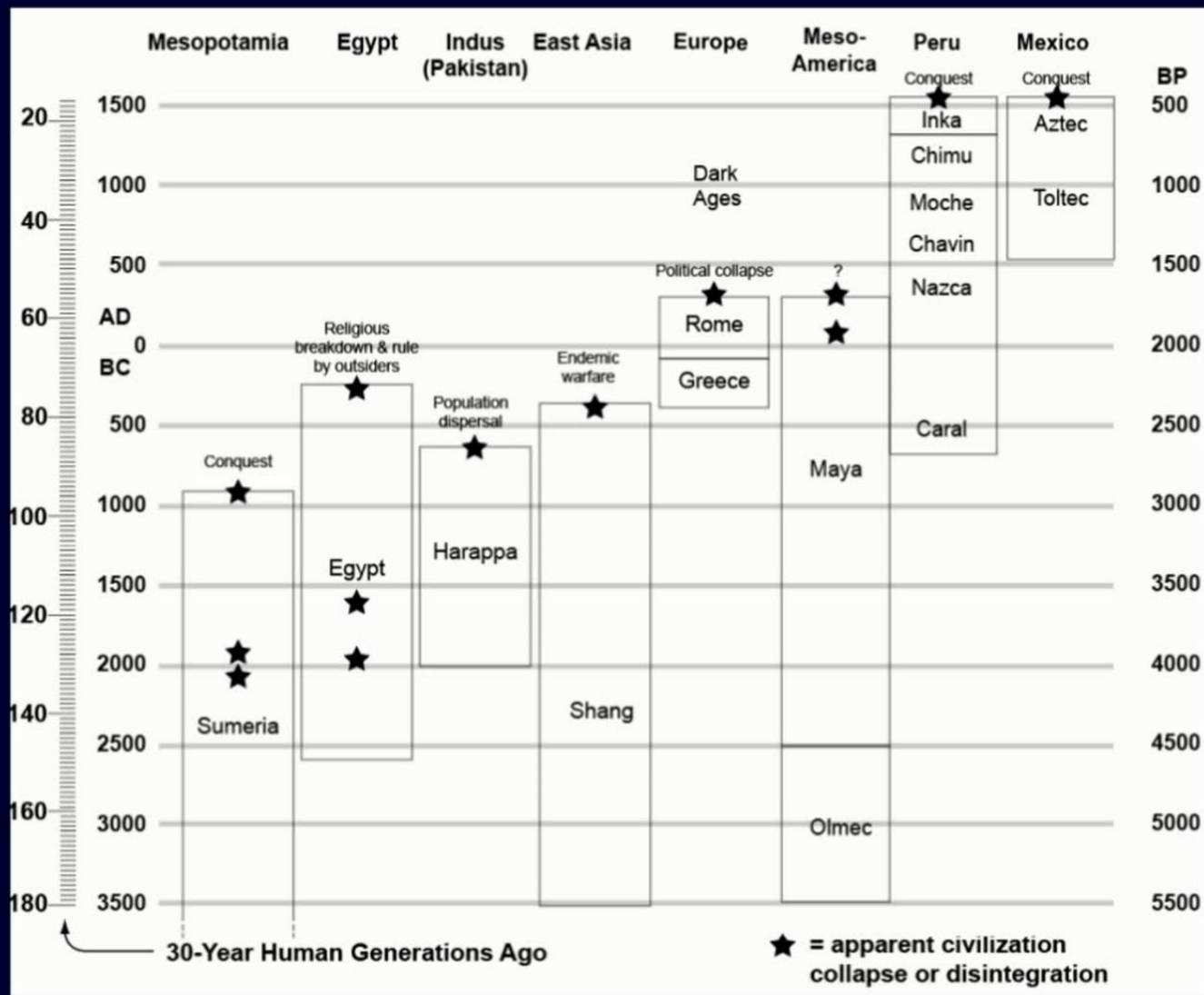
$(\lambda - \lambda)$

$\frac{1}{1+i6}$

$i+1$

$-ieA(\omega)$





Interstellar Voyaging: An Evolutionary Transition (3)

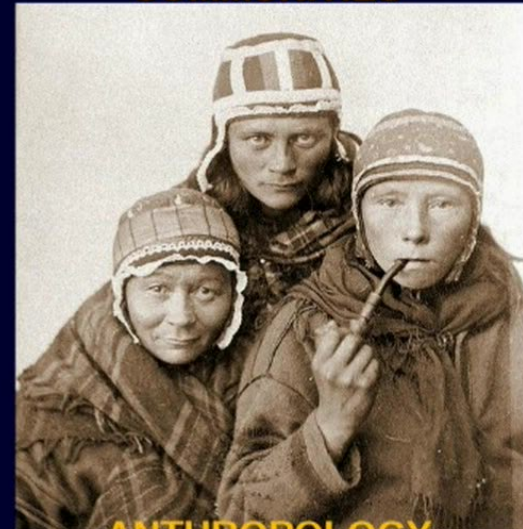
Humanity has long considered space colonization.
Recently however, exploration.
To accomplish colonization, we require a significant shift in thought;

INDIVIDUALS



BIOLOGY

COMMUNITIES



ANTHROPOLOGY

Interstellar Voyaging: An Evolutionary Transition (4)

Where to begin?

My book in production:

Principles of Space Anthropology *Establishing a Science of Human Space Colonization*

PART I BIOLOGICAL ANTHROPOLOGY

PART II CULTURAL ANTHROPOLOGY

PART III EXOARCHAEOLOGY AND MATERIAL CULTURE

PART IV SPACE COLONIZATION AS ADAPTIVE EVOLUTION

Focus of this
talk

Interstellar Voyaging: An Evolutionary Transition (5)

People are biological = biology evolves.

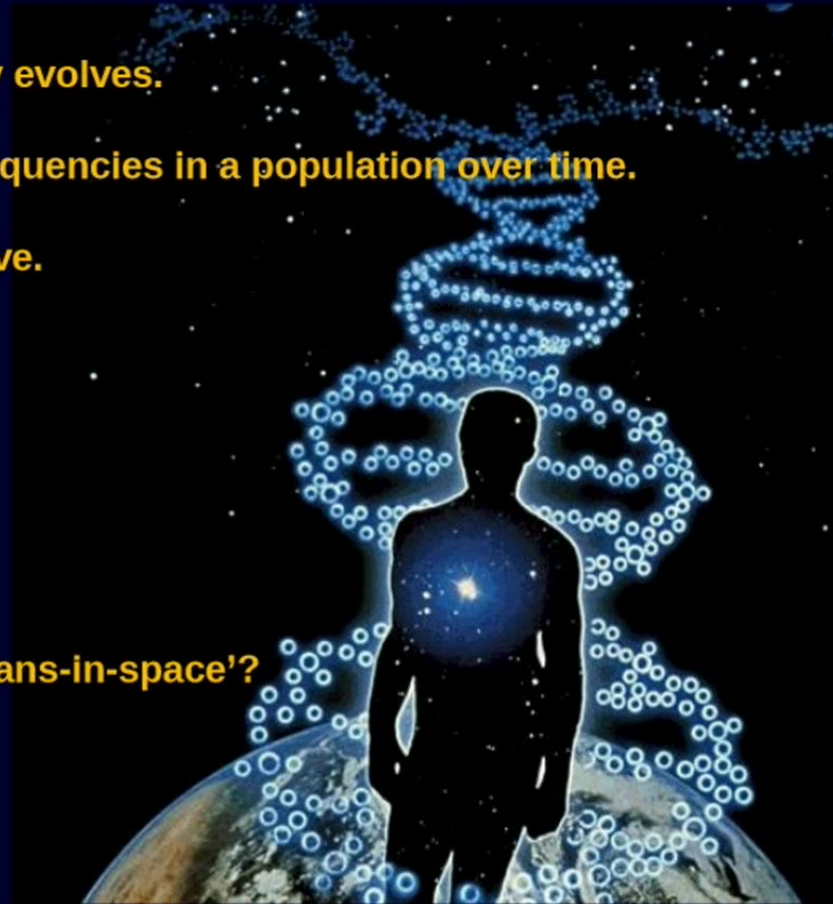
Evolution = change of gene frequencies in a population over time.

Our genome continues to evolve.

Main factors

- Mutation
- Migration
- Selection
- Drift

How do these play out in 'humans-in-space'?

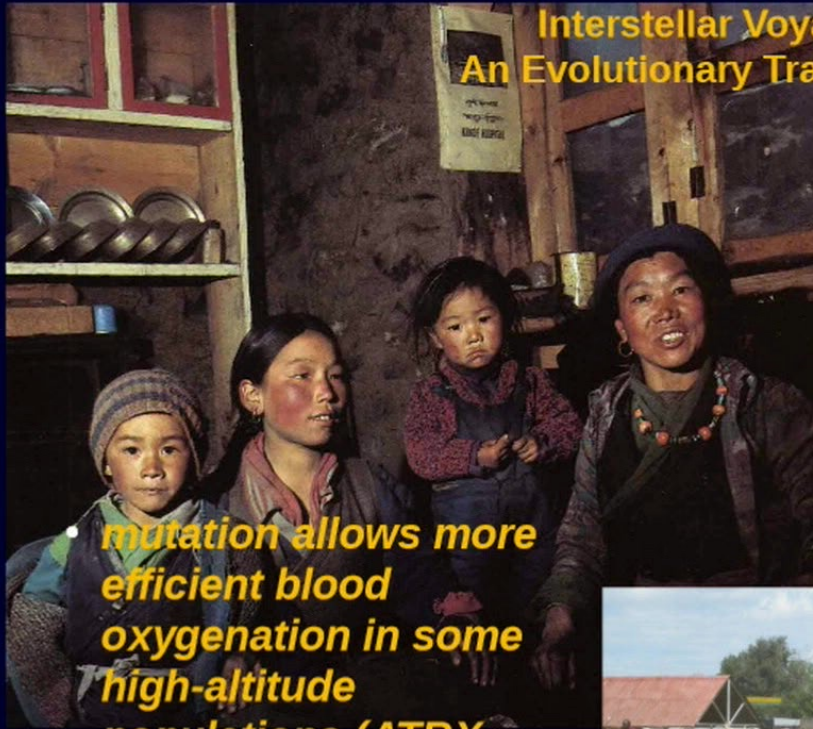


Interstellar Voyaging: An Evolutionary Transition (6)

Mutation

- **result of mutagenesis**
 - **mutagens e.g. x-rays, cosmic rays**
 - **failure of repair mechanisms**
- **mutagenesis introduces variation**
- **variation = diversity**
- **diversity = genetic health of a population**

Interstellar Voyaging: An Evolutionary Transition (7)



- **mutation allows more efficient blood oxygenation in some high-altitude populations (ATRX gene)...**

- **mutation allows adult lactose tolerance for half the world's population**



Interstellar Voyaging: An Evolutionary Transition (8)

- **We can expect that both beneficial and deleterious mutations will arise off-Earth.**
- **Brings us to selection (next slides)**

gas composition (e.g. 60% oxygen?)
gas pressure (c.1/3 Earth normal?)
gravity variation from 1g?
- **These will differ from Earth Normal conditions that have shaped human embryo development for millions of years.**

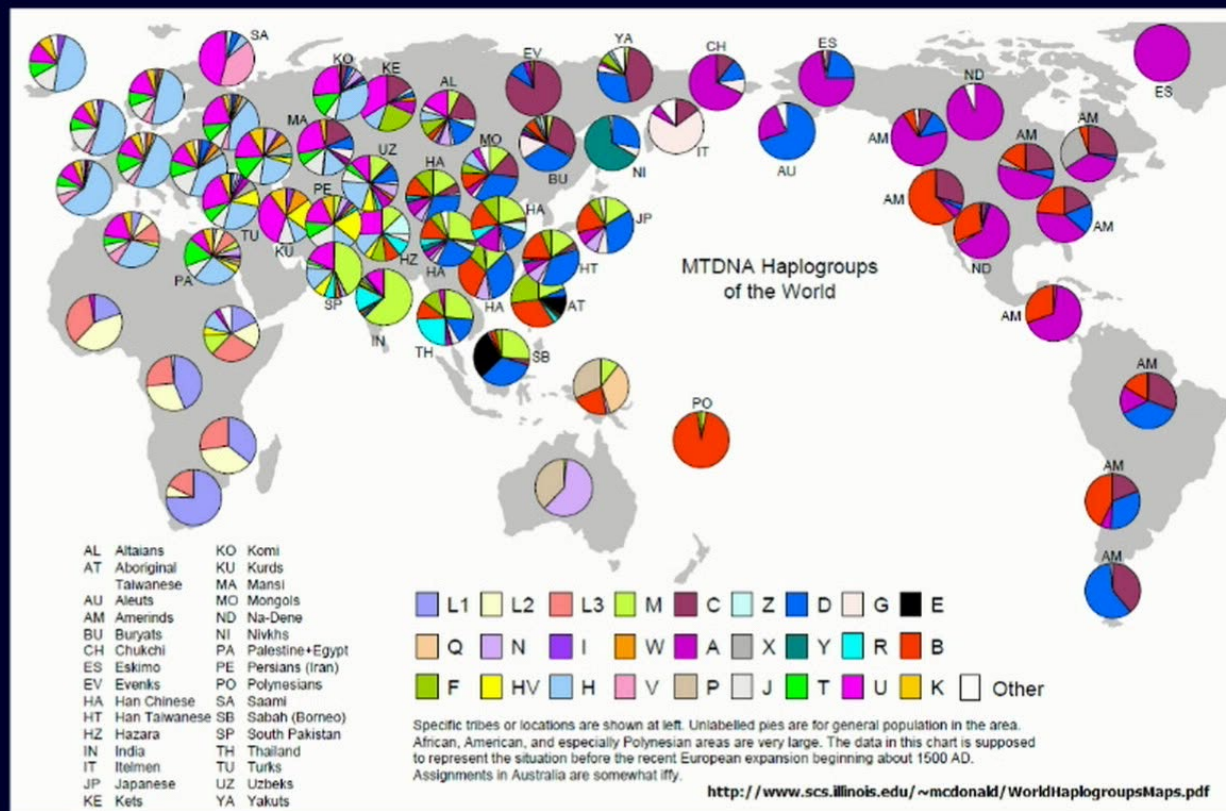
Interstellar Voyaging: An Evolutionary Transition (9)

Migration

- introduces or reduces variation
- 'founder effect' will be strong with population c.40,000
- must represent global human diversity
- but should screen against worst of mendelian disorders

- ☐ caution! 'melting of mendelian paradigm!' ☐

Interstellar Voyaging: An Evolutionary Transition (10)



- **Who will compose “the 40,000” for an Ark?**
- **Who will compose the population of a gradually-growing Mars settlement?**

Interstellar Voyaging: An Evolutionary Transition (11)

Selection

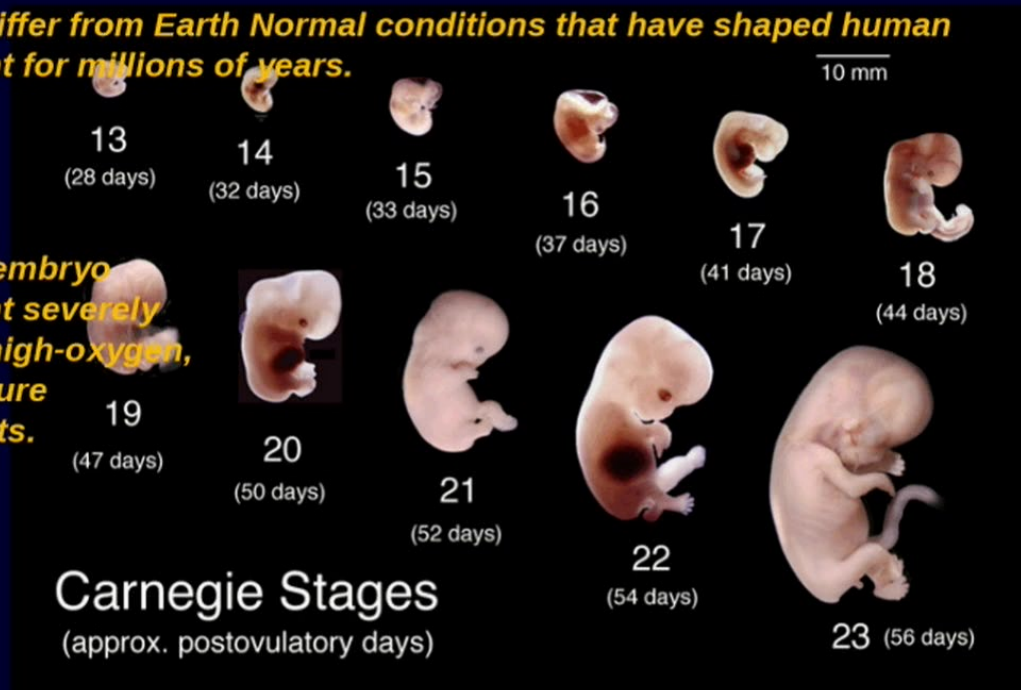
- reduces variation by eliminating deleterious variations
- Many in 'Developing world' 'still' under selection e.g. against disease
- 'Developed world' = selection current in fetal chemistry, found to include gasoline and pesticides.
- Selection will return on all scales:
 - Earth orbital
 - L-point
 - moon
 - Mars
 - interstellar ark

Interstellar Voyaging: An Evolutionary Transition (12)

- The new 'selective environments' for humanity will include:
 - New gas composition (e.g. 44% oxygen?)
 - New gas pressure (c.1/3 Earth normal?)
 - New gravity variation from 1g
- *These will differ from Earth Normal conditions that have shaped human development for millions of years.*

- **Examples:**

- **Amphibian embryo**
- **development severely**
- **affected in high-oxygen,**
- **lower-pressure**
- **environments.**



Interstellar Voyaging:
An Evolutionary Transition (13)

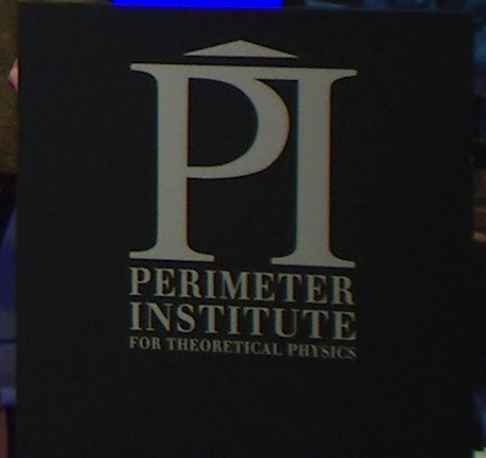
Selection

- Likely greater infant mortality rates than in 'Developed World' over last century.

reproductive ethics
moral philosophy
'Gatacca' phenomenon
(Hawking's Motor Neuron Disease genetics
probabilistic, not deterministic)
- How long should we 'push' an Earth genome off-Earth?

$$\Rightarrow \det \left(1 - \frac{eA}{i\hbar - m} \right) = 1 + \text{diagrams} + \dots$$
$$= \exp \left[\text{diagrams} + \dots \right]$$

Handwritten diagrams include Feynman diagrams with circles and lines, and a diagram with a circle and a wavy line labeled $i+1$. The text $(-ieA(i))$ is also visible.



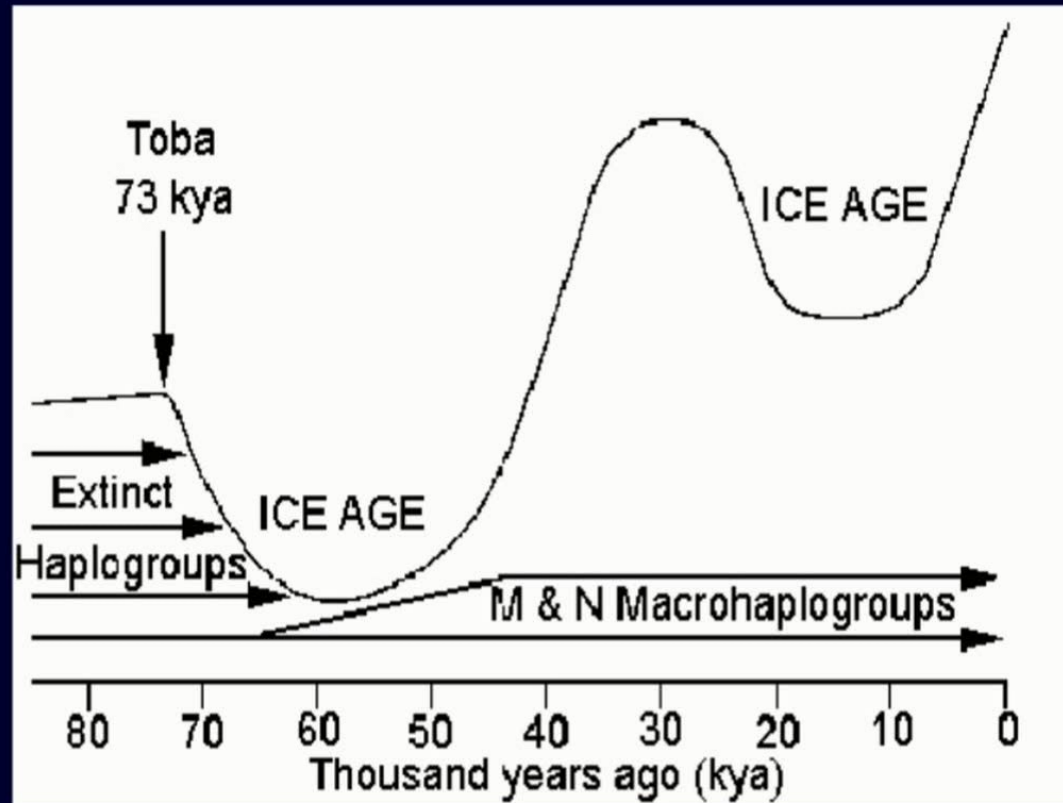
Interstellar Voyaging: An Evolutionary Transition (14)

Drift

- Random increase or decrease of a gene
- Can be linked to other genes
- 'neutral' theory of evolution
- You don't have 1.2 children,
• you have whole numbers, e.g. 1 or 2 etc.

Interstellar Voyaging: An Evolutionary Transition (15)

- *Drift can include bottleneck effect of catastrophe:*





Interstellar Voyaging: An Evolutionary Transition (16)

So for Biological Survival (see Raup, Vermeij):

- **Be genetically diverse.**
 - **Be numerous.**
 - **Be widespread.**
- **These are precisely the factors leading to longevity of species in the fossil record.**
 - **Learn from evolution!**
e.g. “An Evolutionary Framework for Human Space Colonization”

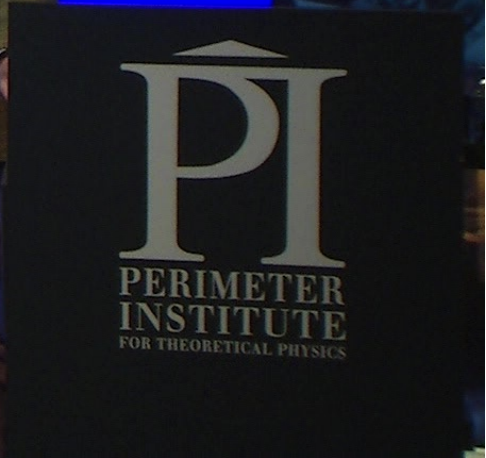
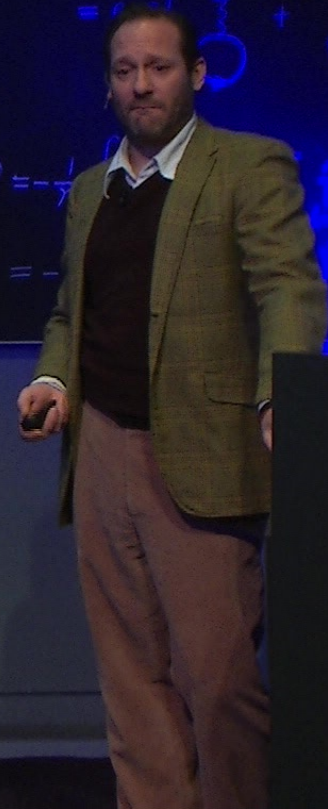
Interstellar Voyaging:
An Evolutionary Transition (17)

Genetically diverse



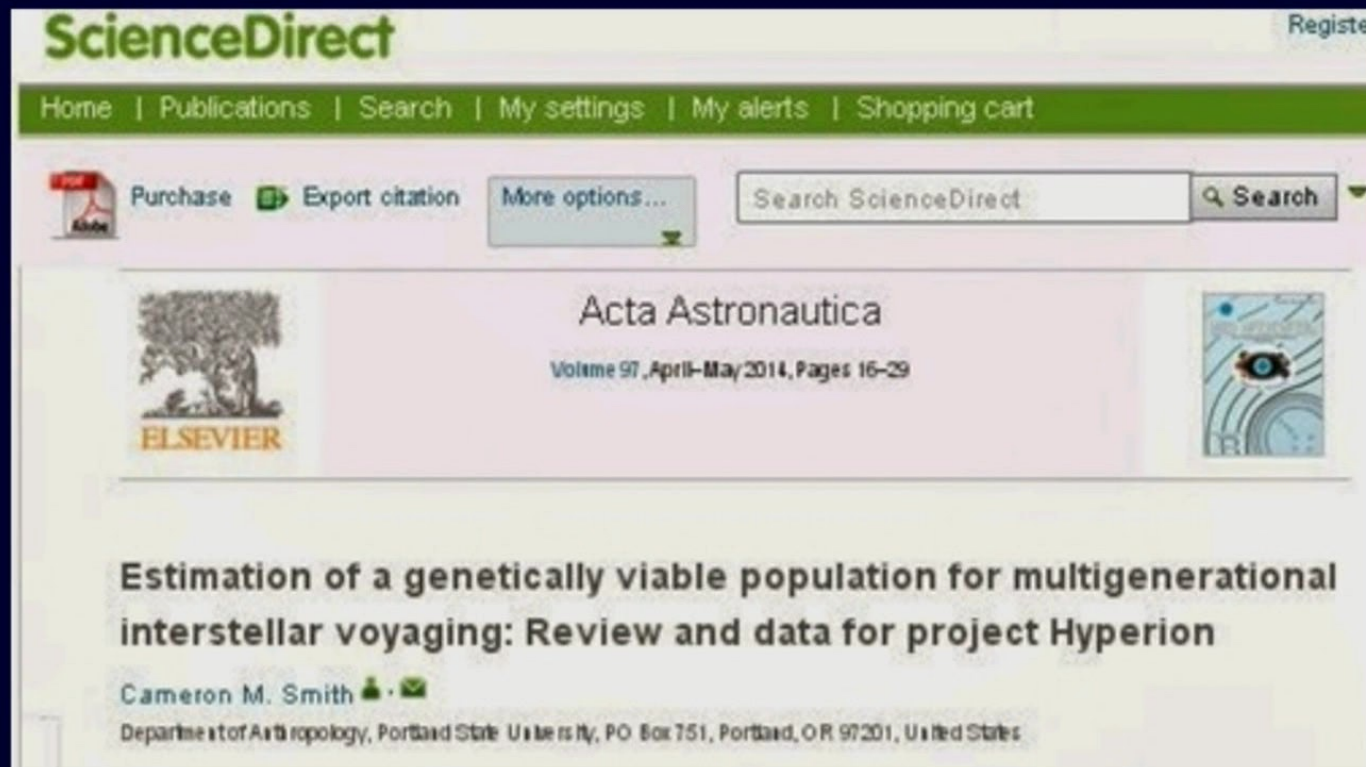
$$\Rightarrow \det \left(1 - \frac{eA}{i\hbar - m} \right) = 1 + \text{[diagram]} + \text{[diagram]} + \text{[diagram]} + \dots$$

The diagram shows a series of terms in a determinant expansion. The first term is 1. The second term is a circle with a wavy line entering from the left and exiting from the right, with a cross in a circle at the exit. The third term is a circle with two wavy lines entering from the left and exiting from the right, with crosses in circles at the exits. The fourth term is a circle with three wavy lines entering from the left and exiting from the right, with crosses in circles at the exits. The terms are separated by plus signs. To the right of the main equation, there is a partial equation: $\frac{1}{i\hbar - m} (-ieA(\omega))$.



Interstellar Voyaging: An Evolutionary Transition (18)

**Numerous do not work with “Minimum Viable Population”
rather, cultivate large numbers quickly**



The screenshot shows the ScienceDirect website interface. At the top, the ScienceDirect logo is on the left, and a 'Register' link is on the right. Below the logo is a navigation bar with links for Home, Publications, Search, My settings, My alerts, and Shopping cart. A secondary bar contains icons for Purchase, Export citation, and More options..., followed by a search box labeled 'Search ScienceDirect' and a 'Search' button. The main content area features the Elsevier logo on the left, the journal title 'Acta Astronautica' in the center, and the issue information 'Volume 97, April-May 2014, Pages 16-29' below it. On the right is a small thumbnail image of the journal cover. The article title 'Estimation of a genetically viable population for multigenerational interstellar voyaging: Review and data for project Hyperion' is displayed in a large font. Below the title, the author's name 'Cameron M. Smith' is shown with a profile icon and an email icon. At the bottom, the author's affiliation is listed: 'Department of Anthropology, Portland State University, PO Box 751, Portland, OR 97201, United States'.

Table 2
Survey of effective and census population data.

N_e low	N_e high	N_e average	MVP average	Organism code	Reference
			5000	Animal	[47]
1000	5000	3000	15,000	Animal	[50]
			4500	Animal	[66]
50	500	275	2475	Animal	[35]
			2000	Comp Sim	[67]
			5500	Comp Sim	[49]
			> 2500	Comp Sim	[68]
1000	5000		15,000	Comp Sim	[50]
556	1250		8750	Comp Sim	[69]
		12,300	24,600	Hominoidea	[70]
		21,300	42,600	Hominoidea	[70]
		25,200	50,400	Hominoidea	[70]
			10,841	Insect	[55]
			2200	Insect	[42]
			5137	Large vertebrate	[55]
9000	12,000	10,500	21,000	Later hominin	[63]
8000	11,000	9500	19,000	Later hominin	[63]
7000	9500	8250	16,500	Later hominin	[63]
		18,000	36,000	Later hominin	[71]
		10,000	20,000	Later hominin	[72]
		10,000	35,000	Later hominin	[6]
10,000	100,000	55,000	110,000	Later hominin	[32]
		21,000	64,000	Later hominin	[32]
		8800	17,600	Later hominin	[32]
9000	17,500	13,250	26,500	Later hominin	[40]
		10,000	20,000	Later hominin	[73]
		9640	19,280	Later hominin	[51]
6000	15,000	10,500	21,000	Later hominin	[74]
		10,659	21,318	Later hominin	[41]
		10,000	20,000	Later hominin	[75]
			3876	Mammal	[55]
			3500	Mammal	[76]
			> 3200	Mammal	[77]
		10,400	20,800	Mod human	[70]
		14,000	28,000	Mod human	[78]
		10,000	20,000	Mod human	[32]
10,000	100,000	10,000	20,000	Mod human	[79]
		15,000	30,000	Mod human	[80]
		10,000	20,000	Mod human	[81]
3000	15,000	9000	18,000	Mod human	[82]
		10,000	30,000	Mod human	[23]
		35,000	70,000	Mod human	[83]
			325	Mod human	[54]
3100	7500	5300	15,900	Mod human	[84]
		5394	10,788	Mod human	[51]
		770	1540	Mod human	[51]
		10,000	20,000	Mod human	[85]
		10,000	20,000	Mod human	[86]
10,000	20,000	15,000	30,000	Mod human	[53]
		10,000	20,000	Mod human	[41]
		10,000	20,000	Mod human	[41]
			4196	Plant	[55]
			3956	Small vertebrate	[55]

Table 3
Summary of population data surveyed.

Average	N_e	MVP
All studies	18,187	31,810
Animal	1638	
Comp Sim		7813
Hominoidea	19,600	
Insect		6521
Large vertebrate		5137
Later hominin	17,819	51,075
Mammal		3688
Modern human	11,368	21,964
Plant		4196
Small vertebrate		3956
Various primates	49,000	83,846
Vertebrate		5090
All hominins	14,494	21,888

So, how numerous?

With safety factor to maintain MVP above 7,000 = 18,000-44,000

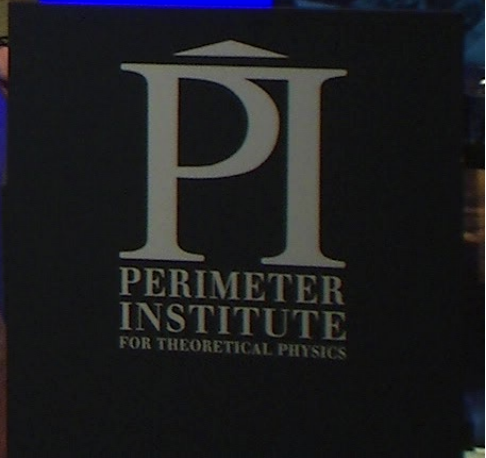
40,000 = 8 * 5,000-person 'villages' or 'towns' = reasonable over 5 gens

$$\Rightarrow \det \left(1 - \frac{eA}{i\beta - m} \right) = 1 + \text{[diagrams]} + \dots$$

$$= \exp \left[\text{[diagrams]} + \dots \right]$$

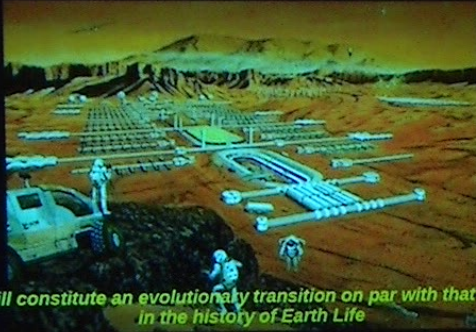
$$\text{tr} \left[\frac{1}{i\beta - m} (1 - ieA(i\omega)) \right]$$

(M)
 $\frac{dx-x}{x}$
 $\frac{1}{1+e}$
 $i+1$



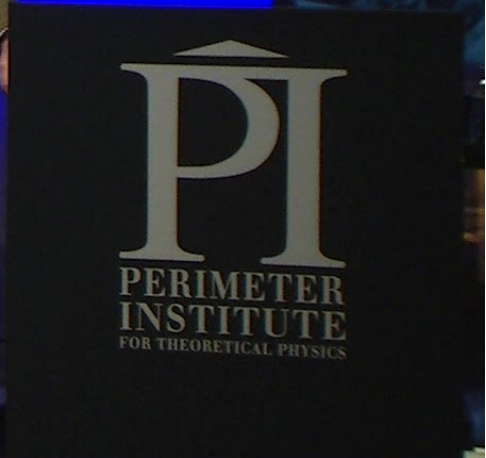
Interstellar Voyaging:
An Evolutionary Transition (19)

Widespread achieved by settlement independent of Earth
biologically, culturally, economically & politically



This will constitute an evolutionary transition on par with that of others
in the history of Earth Life

$$\Rightarrow \det \left(1 - \frac{eA}{i\hbar - m} \right) = 1 + \text{[diagrams]} + \text{[diagrams]} + \text{[diagrams]} + \dots$$
$$= \exp \left[\text{[diagrams]} + \text{[diagrams]} + \text{[diagrams]} + \dots \right]$$
$$dx_i \text{ to } \left[\frac{d}{dt} \left(1 - i e A(\omega) \right) \right]$$
$$\frac{eA}{i\hbar - m}$$



Interstellar Voyaging: An Evolutionary Transition (20)

NOTE evolutionary biology itself undergoing a new synthesis at present, worth consideration for long-term planning

MICROBIOLOGY AND MOLECULAR BIOLOGY REVIEWS, June 2004, p. 173–186
1092-2172/04/\$08.00+0 DOI: 10.1128/MMBR.68.2.173-186.2004
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Vol. 68, No. 2

A New Biology for a New Century

Carl R. Woese*

Department of Microbiology, University of Illinois, Urbana, Illinois 61801

“Science is an endless search for truth. Any representation of reality we develop can be only partial. There is no finality, sometimes no single best representation. There is only deeper understanding, more revealing and enveloping representations. Scientific advance, then, is a succession of newer representations superseding older ones, either because an older one has run its course and is no longer a reliable guide for a field or because the newer one is more powerful, encompassing, and productive than its predecessor(s).”

Interstellar Voyaging: An Evolutionary Transition (21)

'Postgenomic synthesis' e.g. mutualisms, developmental genetics, mutagenesis, epigenetics, etc.

The screenshot shows the eScholarship website interface. At the top left is the eScholarship logo for the University of California. Navigation links include 'About eScholarship', 'Publish/Deposit', 'Browse Content', 'Help', 'My Account', and 'My Saved Items (0)'. A search bar is located at the top right. Below the navigation is a social media follow prompt for Facebook and Twitter. The main header identifies the journal as 'Structure and Dynamics: eJournal of Anthropological and Related Sciences' from UC Irvine. The article title is 'What Anthropologists Should Know About the New Evolutionary Synthesis' by Cameron M. Smith and Julia C. Ruppell. The article content includes the authors' names, their affiliations at Portland State University, and an abstract discussing the re-evaluation of neo-Darwinian evolution in light of modern biological discoveries.

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Title:
What Anthropologists Should Know About the New Evolutionary Synthesis

Journal Issue:
Structure and Dynamics, 5(2)

Author:
Smith, Cameron M., Portland State University, Department of Anthropology;
Ruppell, Julia C., Portland State University, Department of Biology

Publication Date:
2011

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Structure and Dynamics: eJournal of Anthropological and Related Sciences

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What Anthropologists Should Know About the New Evolutionary Synthesis
Smith, Cameron M. and Ruppell, Julia C.

Smith and Ruppell: What Anthropologists Should Know About the New Evolutionary Synthesis

What Anthropologists Should Know About the New Evolutionary Synthesis

Cameron M. Smith¹ and Julia C. Ruppell²

Portland State University: Departments of ¹Anthropology and ²Biology

Abstract: Discoveries of modern biology are forcing a re-evaluation of even the central pillars of neo-Darwinian evolution. Anthropologists study the processes and results of biological and biocultural evolution, so they must be aware of the scope and nature of these changes in biology. We introduce these changes, comment briefly on how they relate to anthropology, and suggest numerous readings to introduce anthropologists to the

Interstellar Voyaging: An Evolutionary Transition (22)

Cultural Evolution

Where to begin?

Human Universals

- * organizing variables found in all human groups
- * 'contents' differ but must be addressed by all humans

Basic Needs

Metabolism
Reproduction
Bodily comforts
Safety
Movement
Growth
Health

Cultural Responses

foodways
kinship rules
clothing and shelter
protective arrangements
activities
training / enculturation
hygiene

Interstellar Voyaging: An Evolutionary Transition (23)

Example

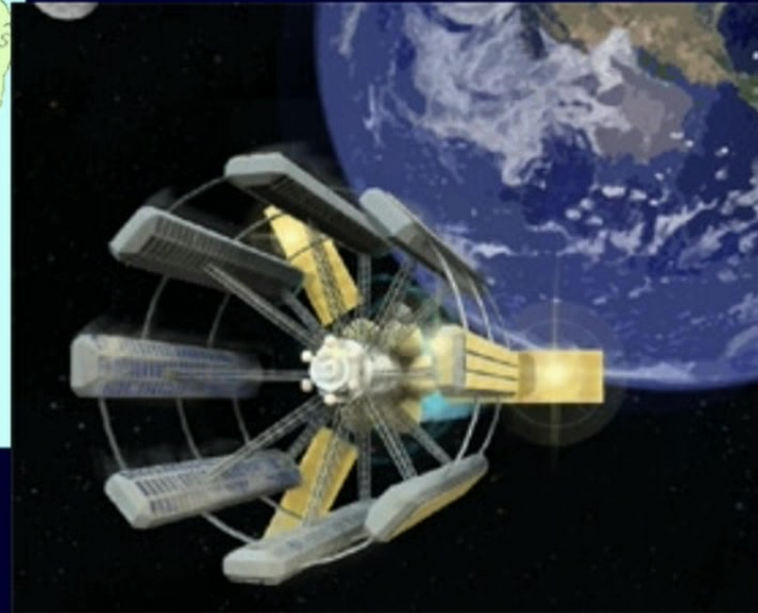
Language	Specific spoken and gestural (bodily) systems of communication, including vocabularies and grammars.	Some languages assign gender to nouns, while others do not.
----------	--	---

Will language change beyond Earth?

Of course;

1. vocabulary (new phenomena; what use 'whale' on Mars?)
2. gesture, dialect and accent (cannot whistle in Skylab atmosphere)
3. prosody (founding composition of colony sub-populations?)

...and dialect is not without social significance!





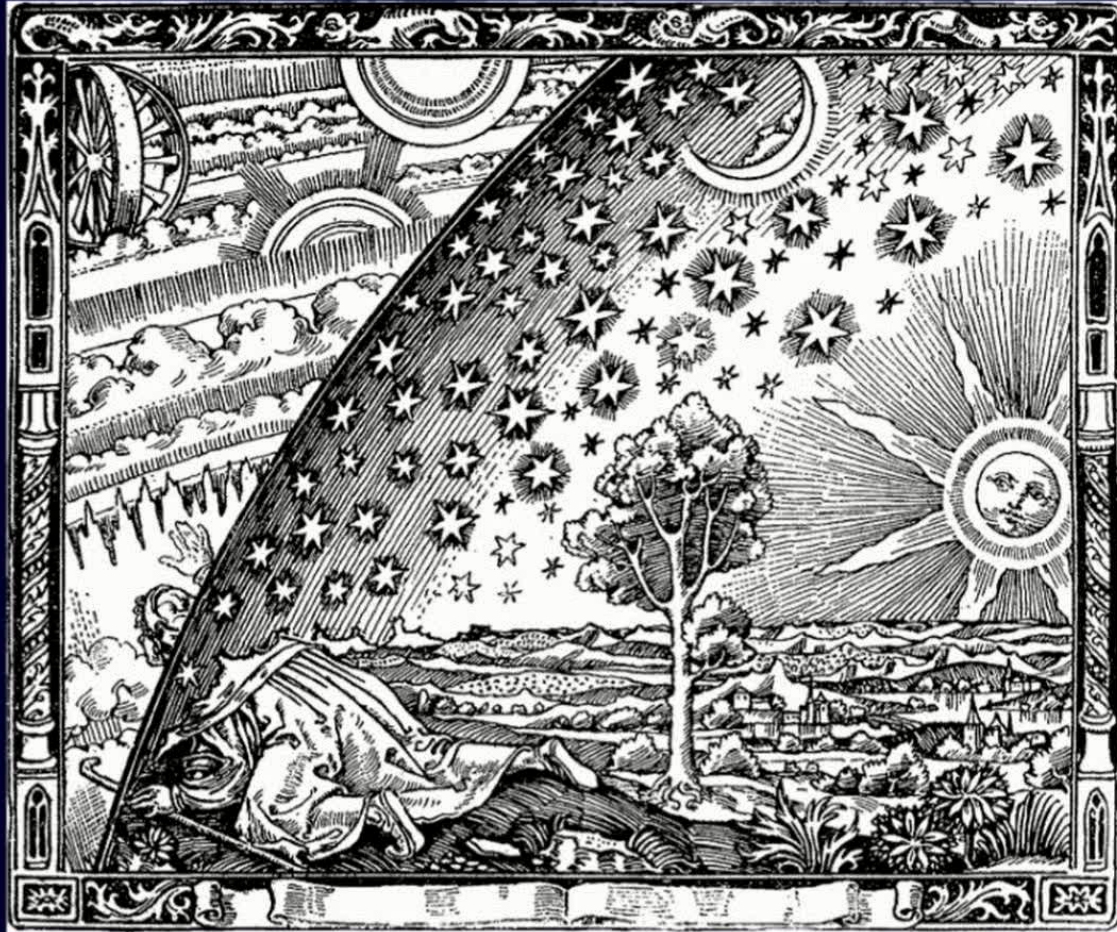
hakarl



svid

Icelandic 'hakarl' = fermented shark...important to traditional life

Nicholas of Cusa



Can we expect such enormous changes of perspective as seen in our history?
Can we expect change in philosophy on order of the Renaissance (or Dark Ages!)?



The outlaw, Grettis of Iceland

How to banish 'to the wilds' on
a starship?

On Mars?

**Interstellar Voyaging:
An Evolutionary Transition (27)**

Add the Dimension of Time

At least – “Three Ages to the Stars”
e.g. 5 centuries to Proxima Centauri Epsilon Eridani:

Age the First Close to Earth, Far from Exoplanet
from Earth, will never see exoplanet

Age the Second Midway
will never see Earth or Exoplanet

Age the Third Close to Exoplanet, Far from Earth
from Midway, anticipating arrival at Exoplanet

