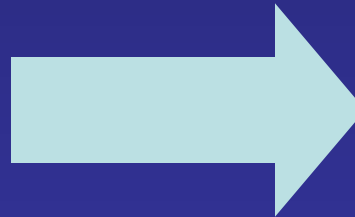


# BIG IDEAS IN BIOLOGY


Six Big Ideas that shape the way  
biologists think about the world of life

(The picture here is *The Firm* album cover; see

<http://www.cduniverse.com/images.asp?pid=1076447&cart=813421952&style=music&image=front&title=Firm+-+Album+CD>

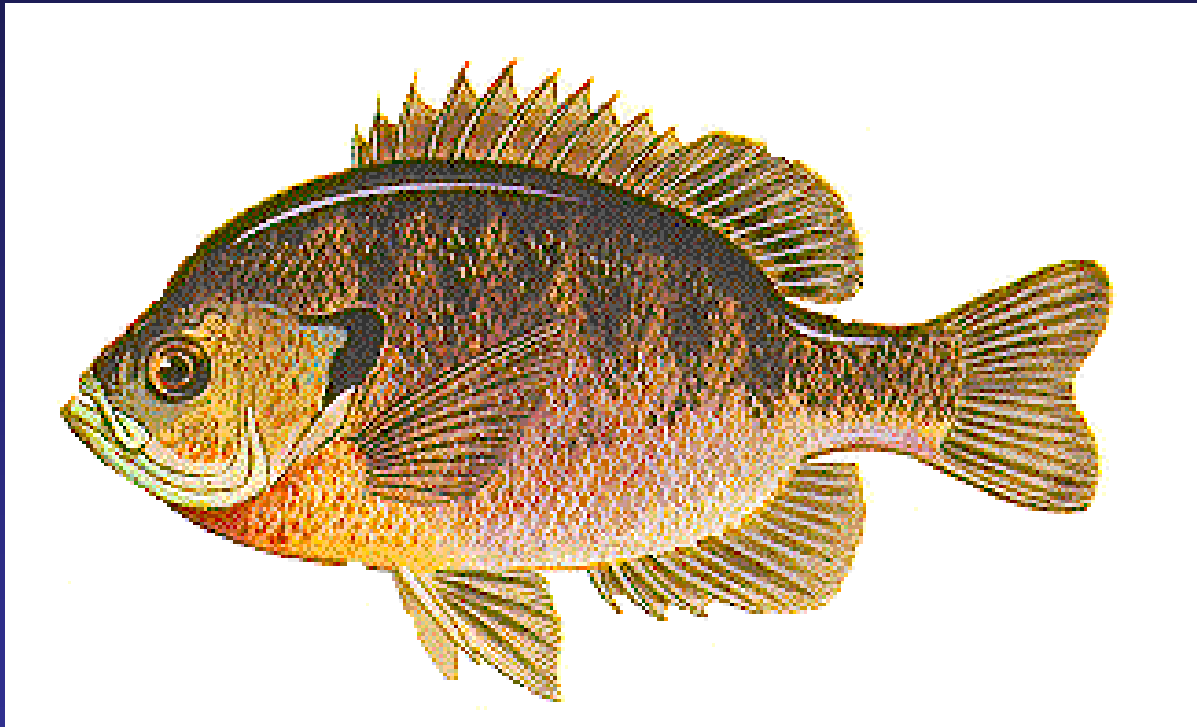


# The Six Big Ideas in Biology\*:

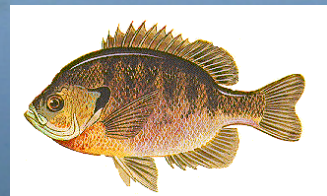
- (1) The origin of eukaryotic cells
- (2) The origin of multi-cellularity
- (3) The concept of an emergent property
- (4) Earth as an organism
- (5) Infection and symbiosis 
- (6) Irreversible change as a constant

\*Not all biologists would pick these six.

# What is a fish?



**Bluegill, *Lepomis macrochirus***



# Parasites of *Lepomis macrochirus*, Reported 1973-77

- *Crepidostomum cornutum*
- *Leuceruthrus micropteri*
- *Proterometra macrostoma*
- *Lerneaea cyprinacea*
- *Leptorhynchoides thecatus*
- *Pomphorhynchus bulbocollii*
- *Acanthocephalus jacksoni*
- *Posthodiplostomum minimum*
- *Homalometron armatum*
- *Neoechnorhynchus cylindratus*
- *Proteocephalus ambloplitus*
- *Bothriocephalus claviceps*
- *Spinitectus carolini*
- *Argulus flavescens*
- *Illinobdella moorei*
- *Myzobdella moorei*
- *Clinostomum marginatum*
- *Eustrongylides* sp
- *Epistylus* sp.
- *Actinocleidus fergusonii*
- *Actinocleidus oculatus*
- *Cleidodiscus nematocirrus*
- *Cleidodiscus robustus*
- *Urocleidus acer*
- *Urocleidus biramosus*
- *Urocleidus dispar*
- *Urocleidus ferox*
- *Urocleidus variabilis*
- *Urocleidus furcatus*
- *Argulus maculosus*
- *Ergasilus arthrosis*
- *Ergasilus caeruleus*
- *Ergasilus centrarchidarum*
- *Ergasilus lizae*
- *Ergasilus tenax*
- *Contracaecum* sp.



# What is a mouse?



Deer mouse, *Peromyscus maniculatus*



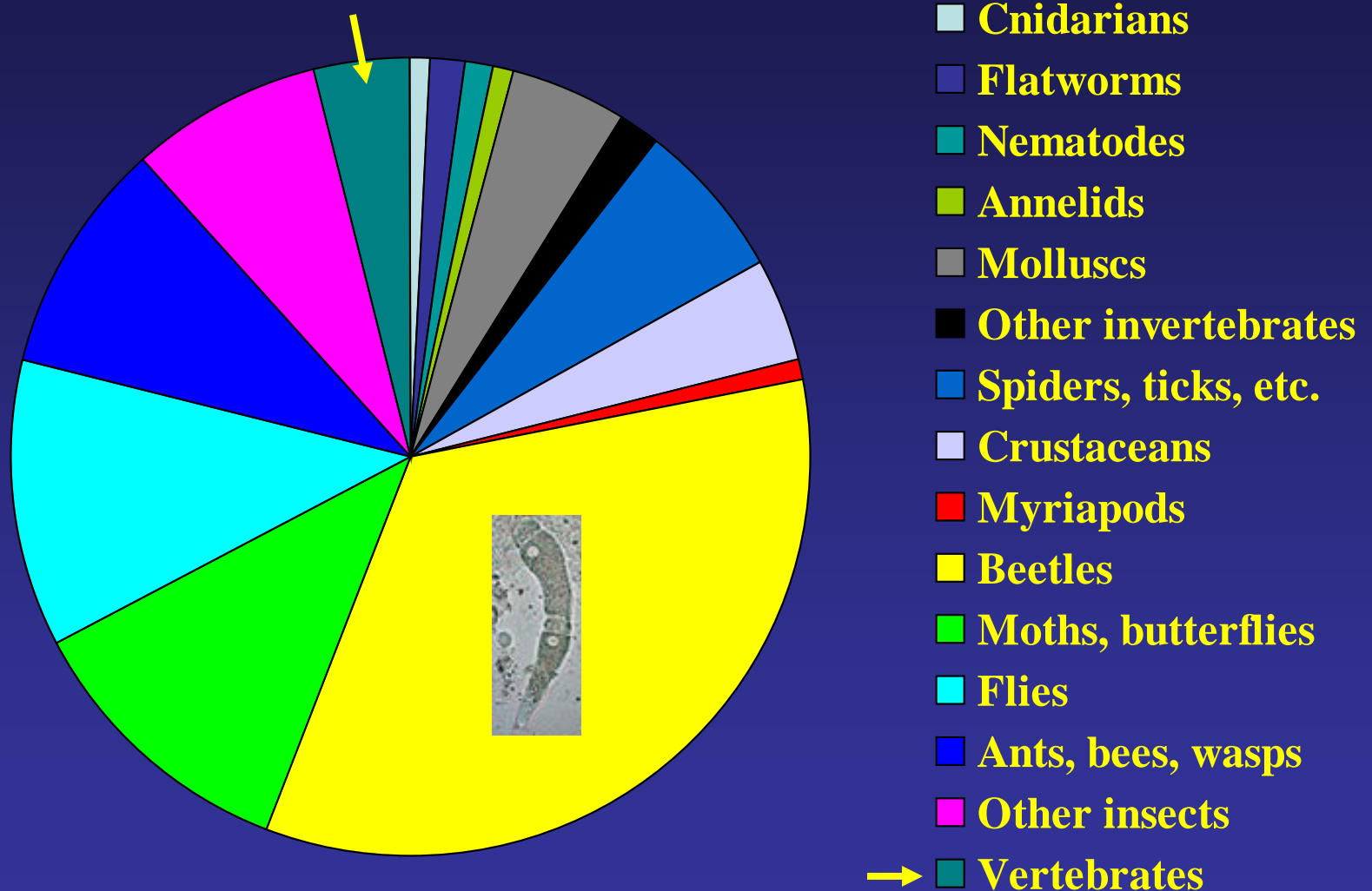
You can tell where this line of thought is headed . . . 

# Parasites of *Peromyscus maniculatus* (arthropods; 1973-1976)

- *Hystrihopsylla dippiei*
- *Stenoponia americana*
- *Meringis parkeri*
- *Epitedia stanfordi*
- *Catallagia decipiens*
- *Anomiopsyllus nudatus*
- *Rhadinopsylla sectilis*
- *Peromyscopsylla hamifer*
- *Peromyscopsylla hesperomys*
- *Dactylopsylla ignota*
- *Orchopeas neotomae*
- *Orchopeas leucopus*
- *Malaraeus sinomus*
- *Malaraeus telchinus*
- *Malaraeus euphorbi*
- *Megabothris abantis*
- *Monopsyllus wagneri*
- *Monopsyllus eumolpi*
- *Cuterebra fontinella*
- *Dermacentor occidentalis*
- *Anomiopsyllus fascicalifornicus*
- *Opisodasys keeni*
- *Meringis cummingi*
- *Neotrombicula brennani*
- *Chatia setosa*
- *Euschoengastia velata*
- *Euschoengastia oregonensis*
- *Comatacarus americanus*
- *Dermacarus jonesi*
- *Odontacarus villosus*
- *Xenodontacarus plumosus*
- *Catallagia mahesoni*
- *Catallagia sculleni*
- *Phalacropsylla allos*



# Familiar and unfamiliar animals:



**So, naturalists observe, a flea  
Hath smaller fleas that on him prey;  
And these have smaller still to bite 'em  
And so proceed *ad infinitum*.**

**Jonathan Swift**

***On Poetry. A Rhapsody*  
(1733)**

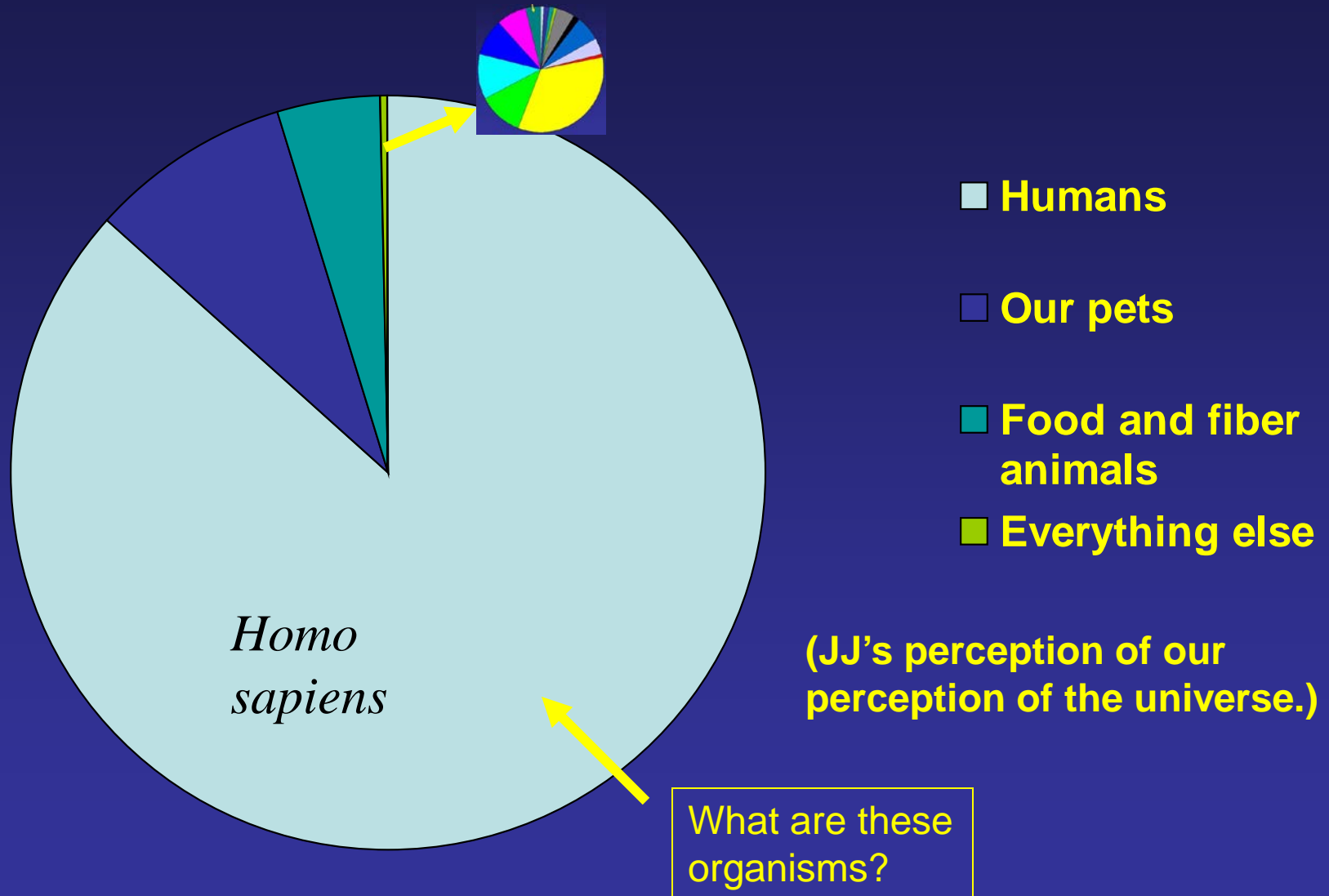
So, naturalists observe, a flea  
Hath smaller fleas that on him prey;  
And these have smaller still to bite 'em  
And so proceed *ad infinitum*.

Thus every poet, in his kind,  
Is bit by him that comes behind.

Jonathan Swift

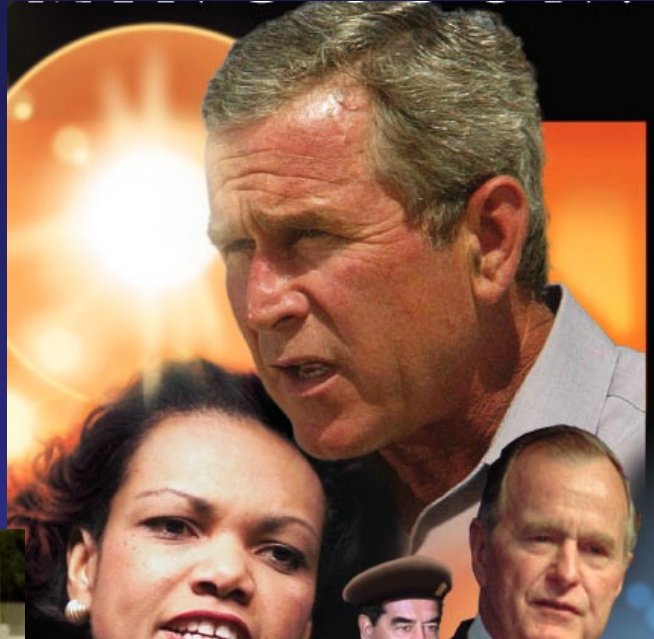
*On Poetry. A Rhapsody*  
(1733)

# The most familiar animals?



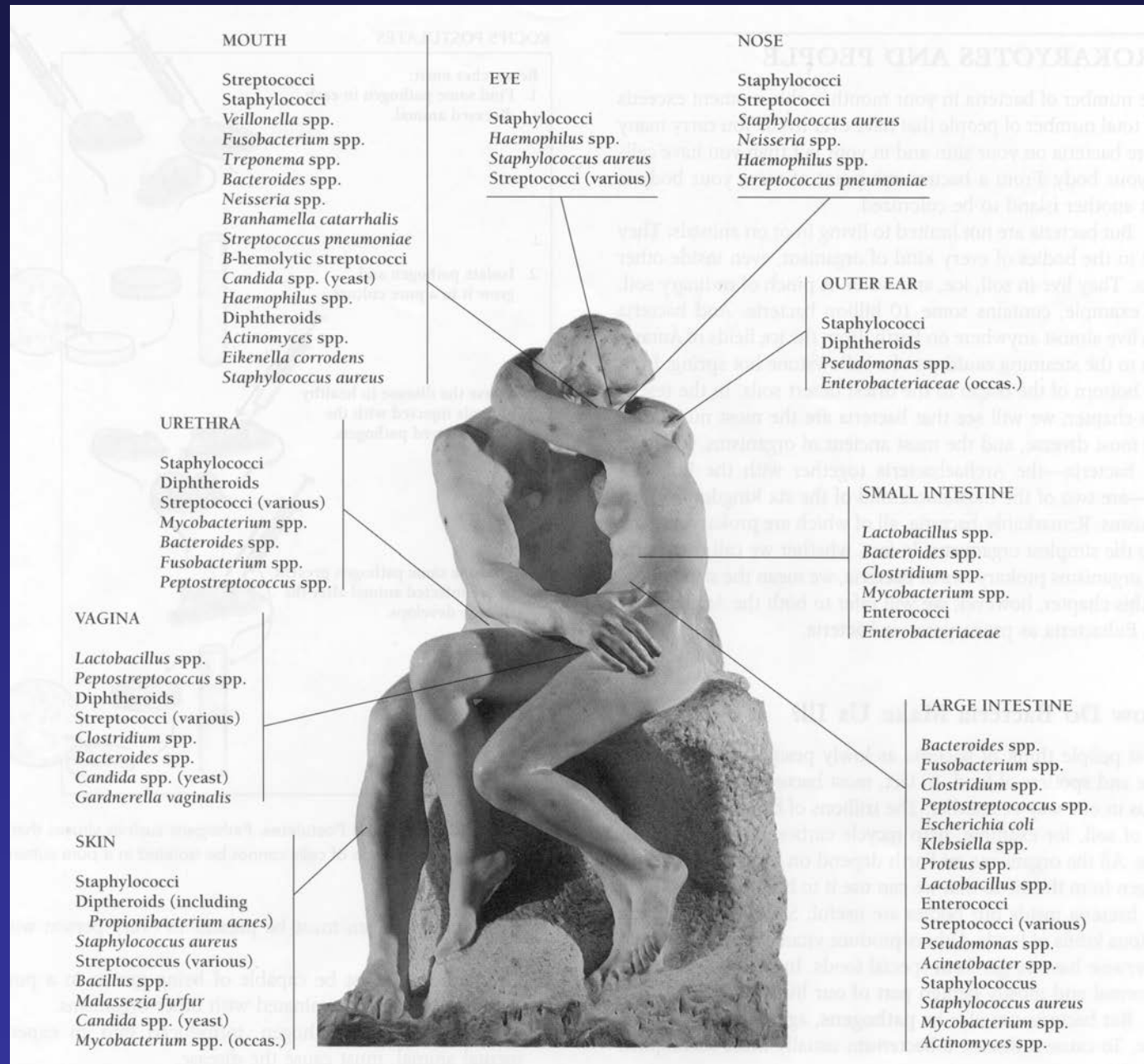


# What is a human being?



(various web sources and friends' emails)





from Tobin and Dusheck - *Asking About Life*

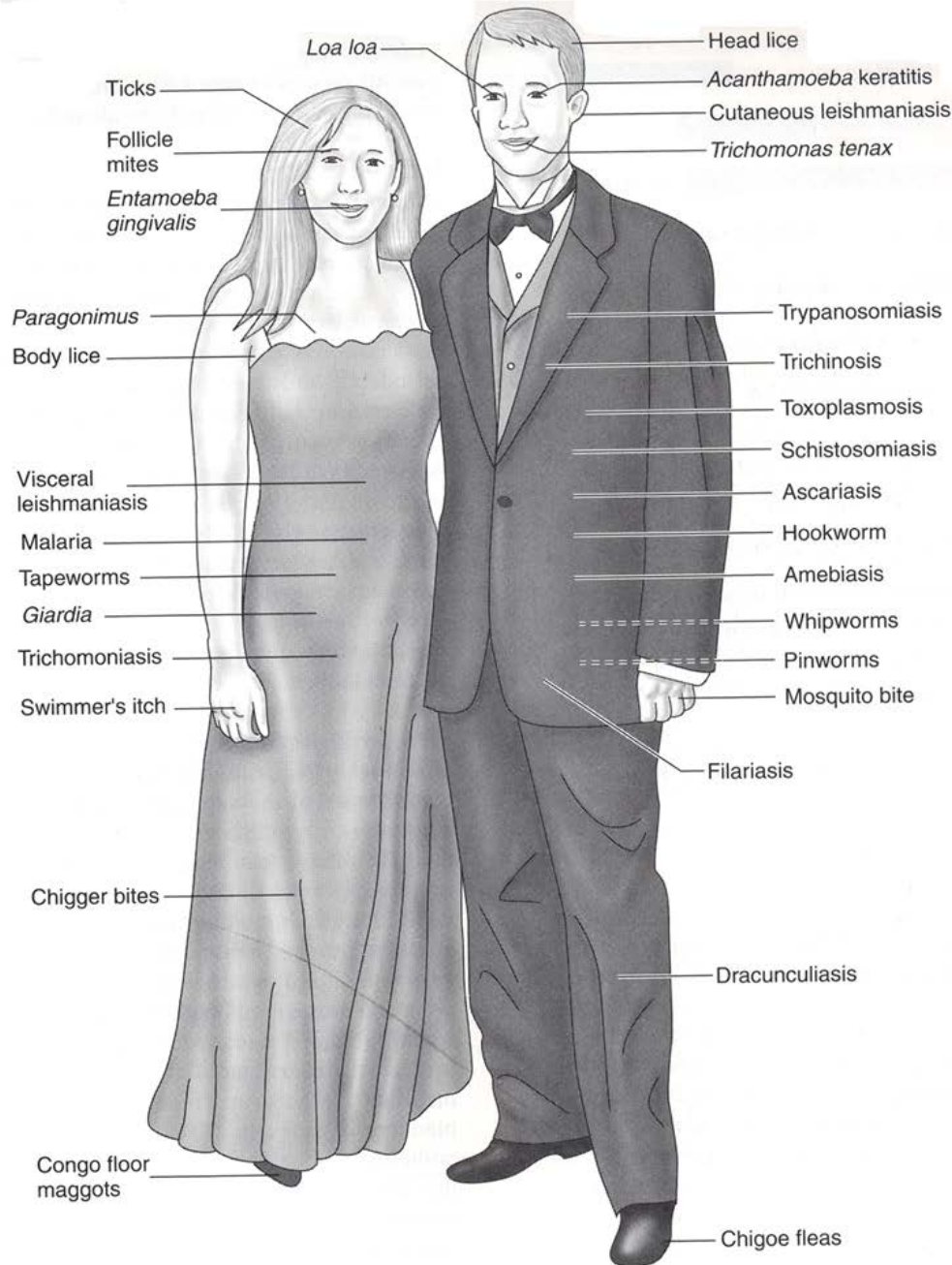
# The notorious fingerprint plate exercise:



**Day 0**



**Day 4 @ room  
temp**



**Q: How do you communicate an idea to college students?**

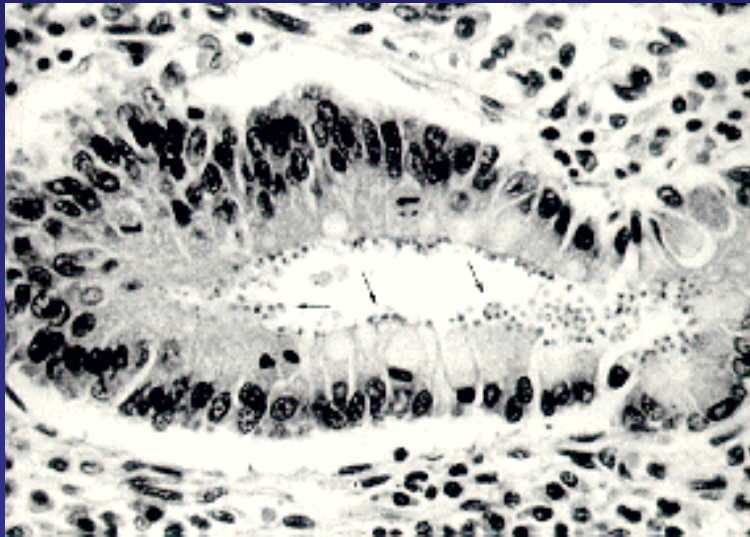
**A: I don't know, but maybe try connecting them with the idea in some new way.**

**“Disease usually results from inconclusive negotiations for symbiosis, an overstepping of the line by one side or the other, a biologic misinterpretation of borders.”**

**Lewis Thomas**

***Lives of a Cell (1974)***

# Interactions between parasites and cultural phenomena: the case of *Cryptosporidium* (*C. parvum*)



<http://www.modares.ac.ir/>

<http://www.ksu.edu/parasitology/>



# **Milwaukee, WI – 403,000 cases of crypto (out of ~1.6 million people) in 1993 epidemic**



<http://www.virtualtourist.com>

MacKenzie et al., 1994, NEJM, 331:161-167.

# Costs associated with outbreak:

<u>Severity</u>	<u>Medical \$</u>	<u>Productivity loss</u>	<u>Total \$</u>
Mild (354,600)	790,760	40,212,000	41,020,000
Moderate (44,000)	2,710,800	18,176,000	20,887,000
Severe (4,400)	28,153,000	6,201,400	43,355,000
Total	31,655,000	64,589,000	96,244,000

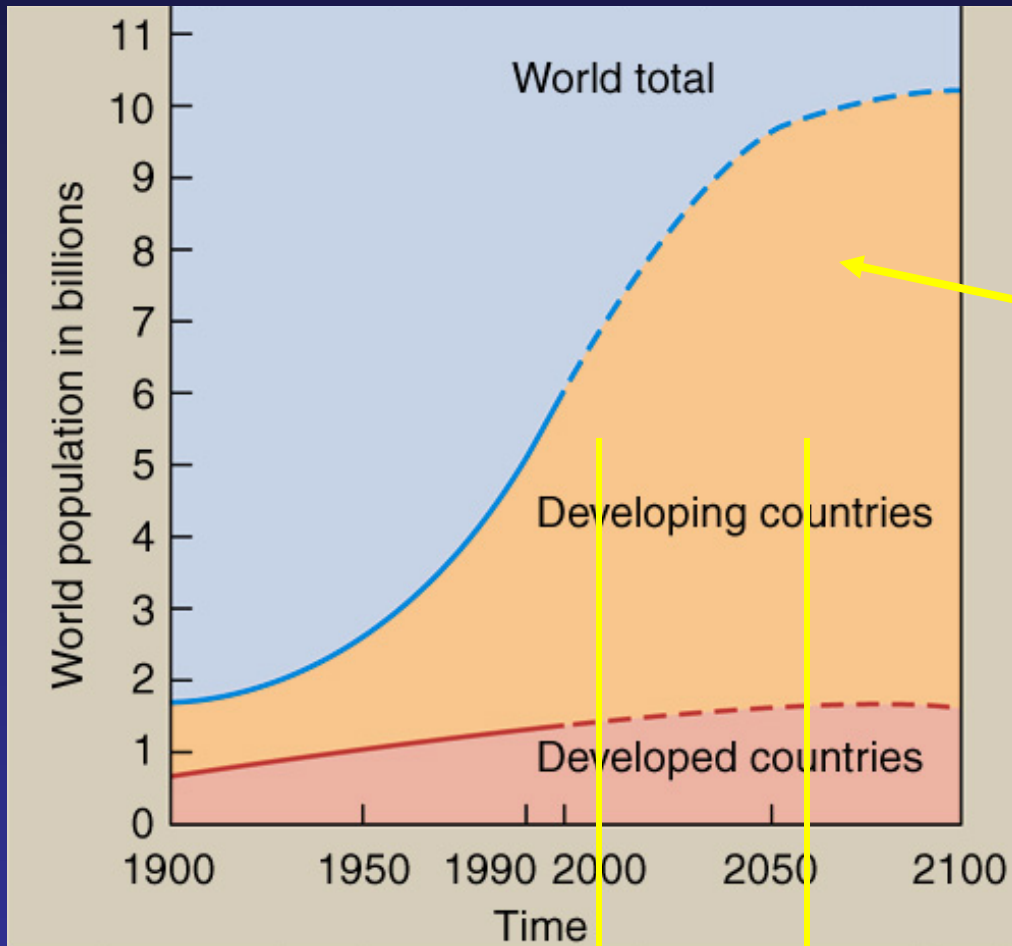
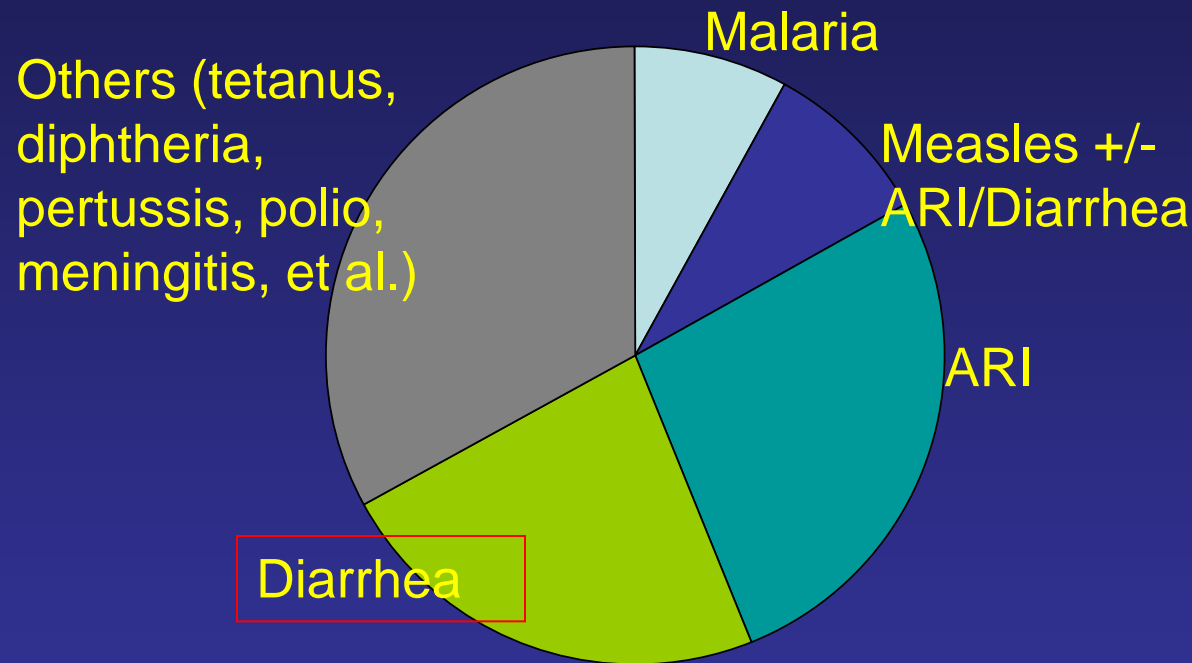


Fig. 2.27, p. 38;  
Johnson, *The  
Living World*

**Q: What is the cultural cost of disease in this segment of humanity, and what will be the expression of that cost?**

# Distribution of deaths in children less than 5 years old in developing countries

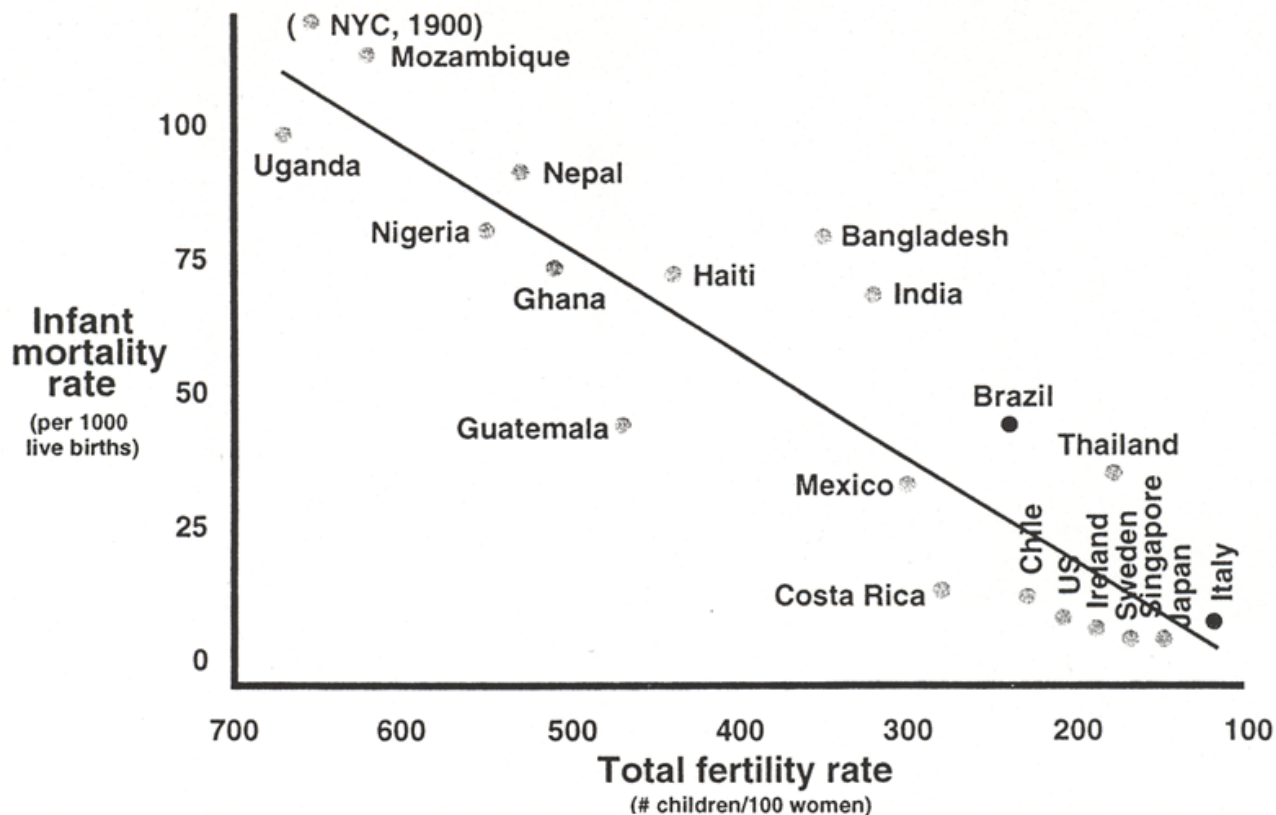


R. Guerrant, 1998, Am. J. Trop. Med. Hyg. 59:3-16.

# Correlations of early childhood (0-2) diarrhea (# days) with cognitive dysfunction @ 6-9 years:

<u>Cognitive test</u>	<u>R (n)</u>	<u>P</u>
McCarthy Draw-A-Design	-0.49(26)	0.012
Backward WISC-III Digit Span	-0.64(10)	0.049
WISC-III Scaled Coding	-0.68(10)	0.031
Forward WISC-III Digit Span	-0.17(26)	0.419
WPPSI-R Mazes 5-11	0.05(26)	0.802





## Correlation of infant mortality and total fertility in selected areas in 1995

(World Bank, 1997, World Development Report, Oxford Univ. Press)

## **Some interesting quotes (cont'd):**

**“The national interest is evermore intimately associated with the process of development of stable and healthy societies in the tropical areas. Indeed. . . Prospects for the very survival of western civilization as we know it are in large part dependent on our ability to share the material benefits of our social system with some 2.5 billion human beings who now exist in mass misery in the poorly sanitated areas of the world.”**

**--Thomas Weller, 1964**

## Some interesting quotes (cont'd):

“... We may now see the dawning of an era when, perhaps for the first time in human evolution, we can begin to perceive the *survival advantage of caring about the other person*, the poor in the tropics.”

--Richard Guerrant, 1998

## **Some interesting quotes (finally):**

**“I know no safe depository of the ultimate powers of the society but the people themselves; and it we think them not enlightened enough to exercise their control with a wholesome discretion, the remedy is not to take it from them, but to inform their discretion by education.”**

**--Thomas Jefferson, 1820 (letter to  
William C. Jarvis)**

# Cultural Transmission and Evolution – A Parasitological Analogy

(The picture here is *The Firm* album cover; see

<http://www.cduniverse.com/images.asp?pid=1076447&cart=813421952&style=music&image=front&title=Firm+-+Album+CD>





J JANOVY In \$10.50  
in the U.S. only

Cultural Transmission  
and Evolution:

A QUANTITATIVE APPROACH

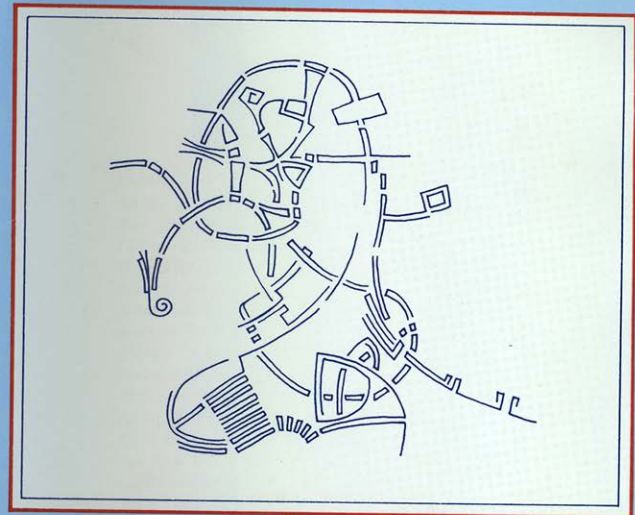
L. L. CAVALLI-SFORZA  
M. W. FELDMAN

MONOGRAPHS IN POPULATION BIOLOGY . 16

# METAMAGICAL THEMAS:

Questing for the Essence  
of Mind and Pattern

DOUGLAS R. HOFSTADTER



*An Interlocked Collection of  
Literary, Scientific, and Artistic Studies*

# Q: What do the following items have in common?

- SUV
- "... weapons of mass destruction . . ."
- Rap music
- "9/11"
- Duct tape
- No Smoking
- Amazon.com
- Powerball
- Super Bowl
- Talk radio
- CNN
- CD
- Digital camera
- An understanding of the role disease plays in politics and war


**A: They are entities that originate in the human brain, and in some cases have taken on material substance, but in other cases have remained only ideas or words, but in all cases have the power to move through human populations in a manner analogous to infectious disease.**

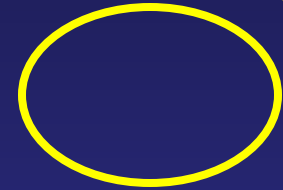
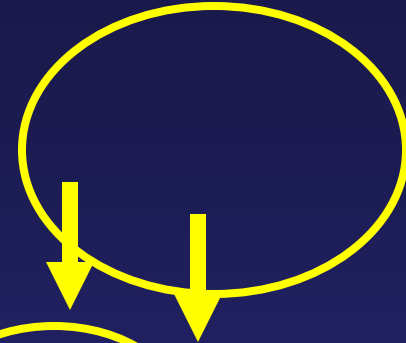
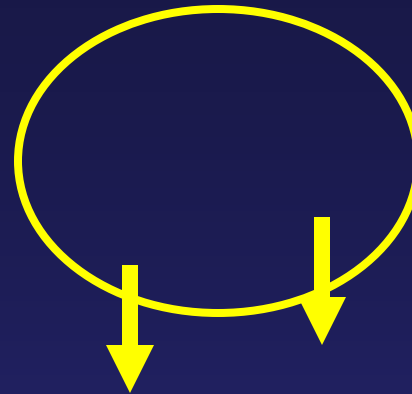
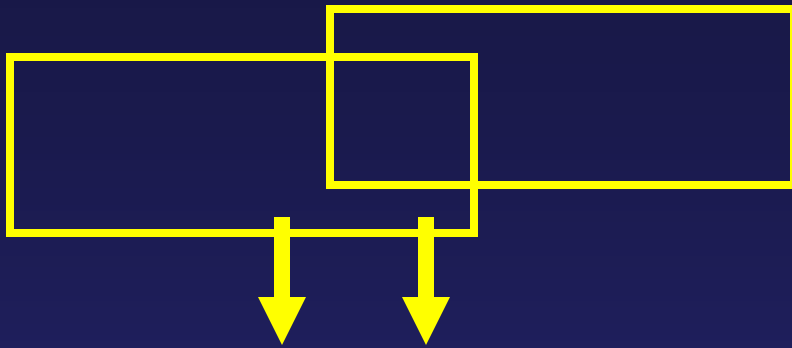
# The Infectivity of Ideas (memes):

**“The first process, growth of awareness, depends on . . . a source--for instance, the makers of a new product, salespeople, or evangelistic users--and transmitters--for example . . . newspapers, journals, radio, or TV. The second step involves . . . decision . . . which may be motivated by economic, emotional, or other types of factors . . .”**

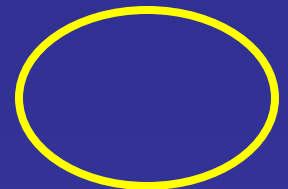
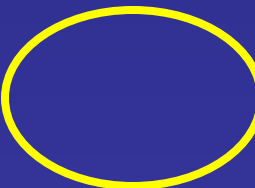
Cavalli-Sforza and Feldman, 1981

# Terminology (there is a LOT of math to go with the vocabulary, if you want it)

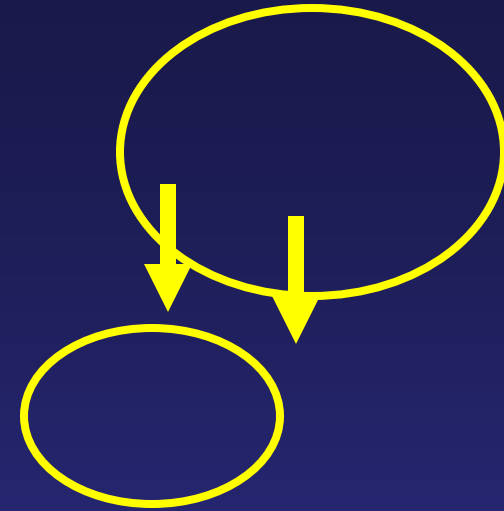
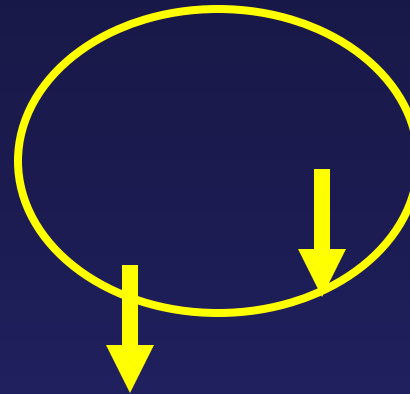
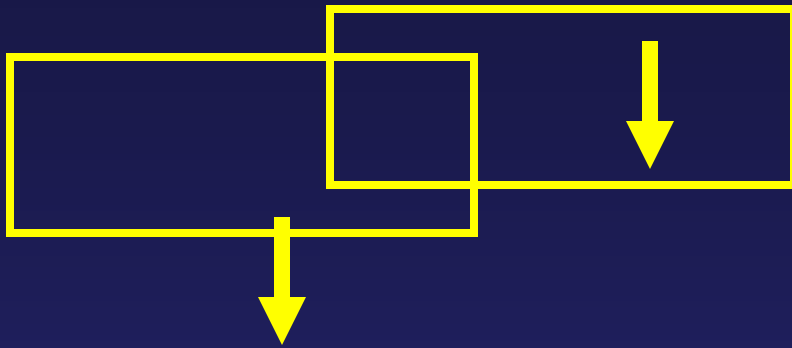
- Vertical transmission
- Horizontal transmission
- Oblique transmission
- Host capture (~ “crossover”)
- Phylogenetic congruence (and topology)
- Mutation (innovation)
- Virulence and infectivity 
- Replication with descent
- Self-referential properties



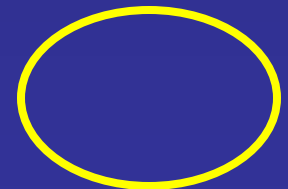
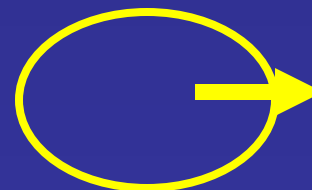
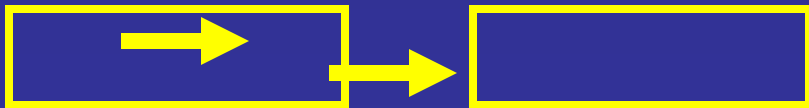
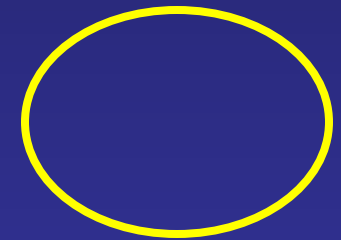
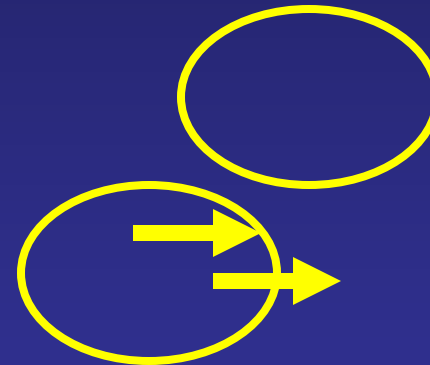
Vertical transmission –  
parent to offspring







Vertical and horizontal transmission – parent to offspring and between members of the same generation



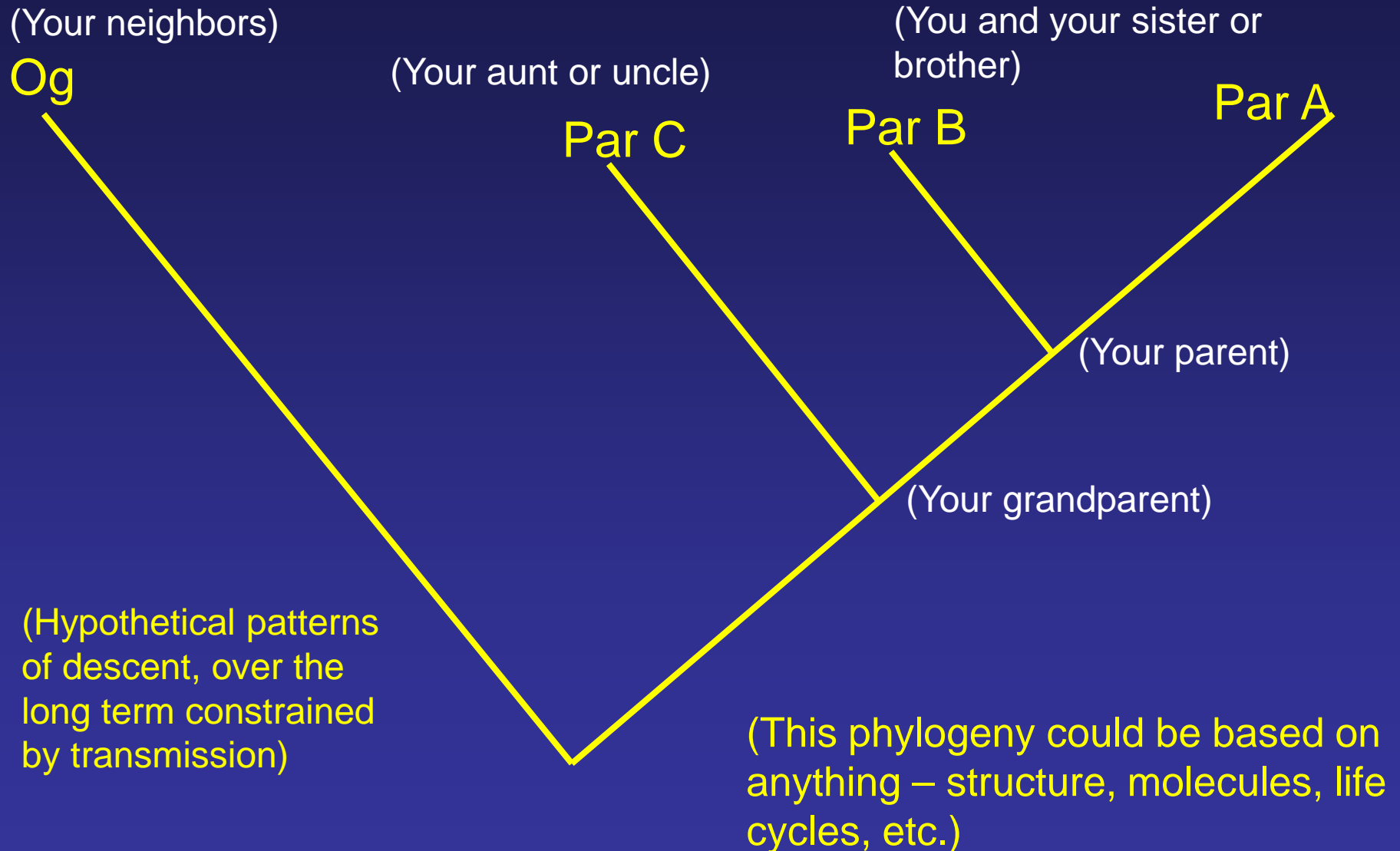
## Vertically-transmitted items (some cultural):

- Religious beliefs ↓
- Voting patterns ↓
- Wealth ↓
- Attitudes (in part) about art, music, etc. ↓↑
- Reading skills and habits ↓
- Use of technology ↓↑
- Pinworms, body lice, *Giardia duodenalis* ↑

# Horizontally-transmitted cultural items:

- Clothing styles
- Peer-group language (slang; verbal short-hand)
- Music
- Old exams (un-infective when transmitted vertically?)
- Use of technology

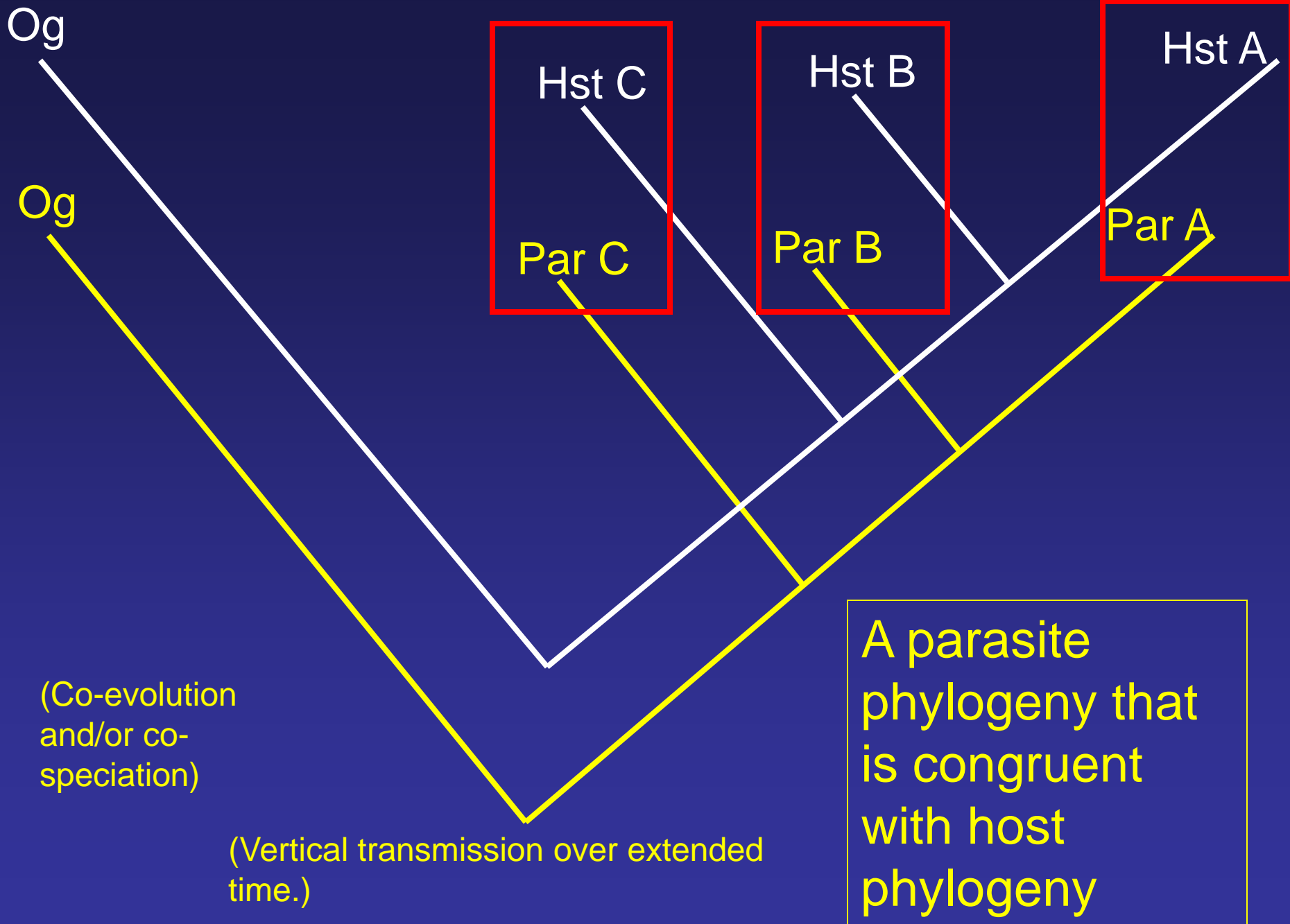
# A very simplified family “phylogeny”:



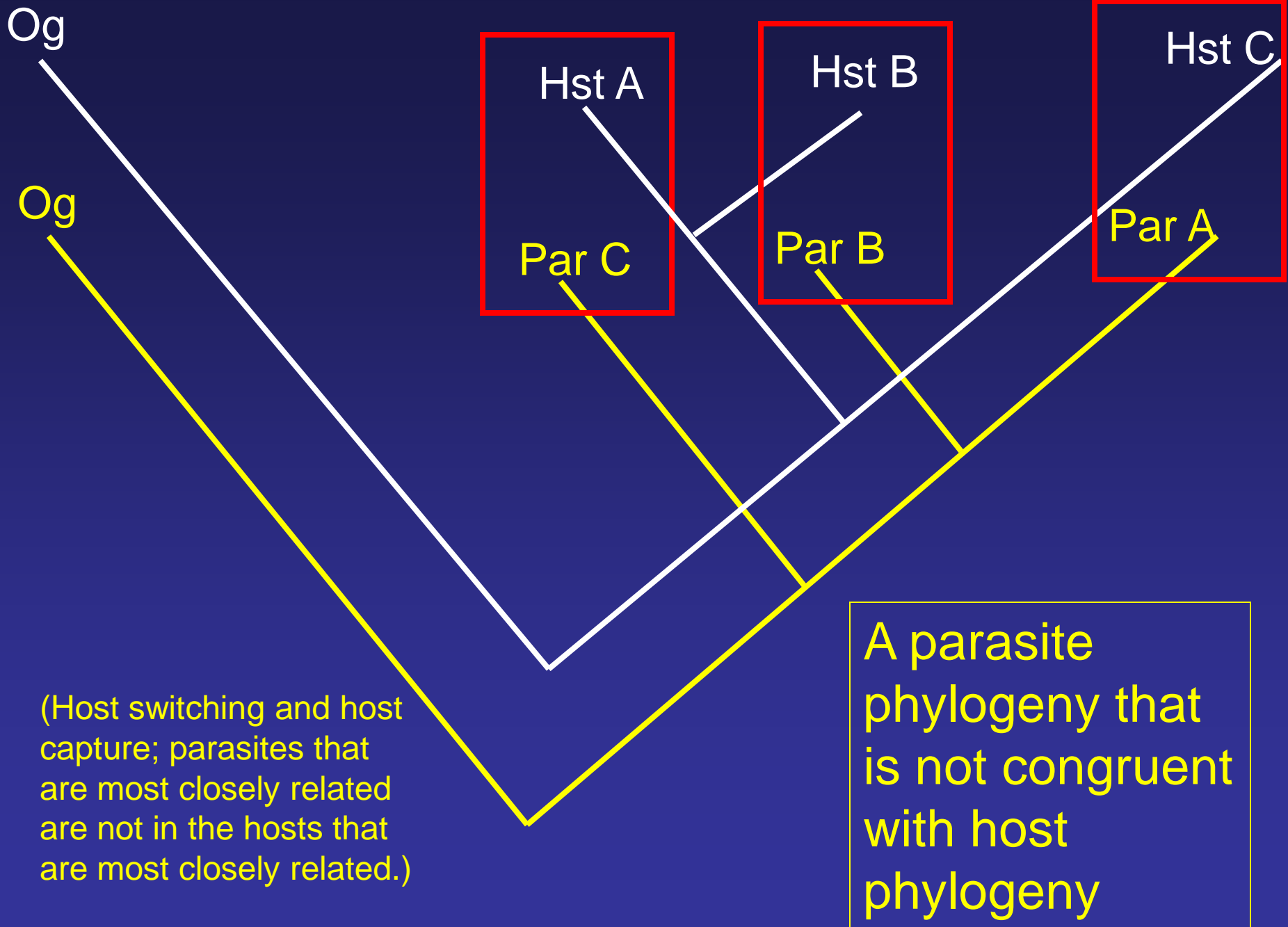
# Cultural items transmitted via descent:

- Silver and jewelry
- Pottery and glassware
- Books (including Bibles)
- Photographs
- Letters, deeds, etc.
- Stories\*
- Furniture\*

\*May be modified in transmission, i.e., may evolve.







# Infectivity and virulence of ideas (memes):

System X

Begin

S(1): Blah.

S(2): Blah, blah.

S(3): Blah, blah, blah.

.

.

S(n): Blah, blah, blah, . . . . .

S(n+1): It is your duty to convince others that  
System X is true

End

(The Hofstadter example)

# Infectivity and virulence of ideas (memes):

System X

Begin

S(1): Anyone who does not believe in  
System X will burn in Hell.

S(2): It is your duty to save others from  
suffering.

End

(The Hofstadter example of viral and self-replicating texts)

# Infectivity and virulence of ideas (memes):

System X

Begin

S(1): Anyone who does not go to Cedar Point Biological Station will burn in Hell.

S(2): It is your duty to save others from suffering.

End

(The Hofstadter example of viral and self-replicating texts)

## Self-replicating viral memes:

- The whales are in danger of extinction.
- The bourgeoisie is oppressing the proletariat.
- The villain is wronging the victim.
- Self-replicating ideas are conspiring to enslave our minds.
- If I don't make a 4.0 GPA at UNL I am a big time failure with no future whatsoever.

# Self-replicating viral memes:

- The whales are in danger of extinction.
- The bourgeoisie is oppressing the proletariat.
- The villain is wronging the victim.
- Self-replicating ideas are conspiring to enslave our minds.
- If I don't make a 4.0 GPA at UNL I am a big time failure with no future whatsoever.
- If I do make a 4.0 GPA at UNL then I will live a long, healthy, and successful life, find a wonderful significant other, stay married\* for 60 years, and have well behaved children.

\*to the same person



“The performance value of an idea depends upon the change it brings to the behavior of the person or group that adopts it. The human group upon which a given idea confers greater cohesiveness, greater ambition, and greater self-confidence thereby receives from it an added power to expand which will insure the promotion of the idea itself. Its capacity to ‘take,’ the extent to which it can be ‘put over’ has little to do with the amount of objective truth the idea may contain.”

Jacques Monod

*Chance and Necessity* (1970)

# Take home messages:

- Ideas, innovations, etc., can behave in a manner analogous to parasites.
- These memes can have infectivity and virulence, and can occur in endemic and epidemic forms.
- Memes can, in a manner analogous to parasites, alter the socio-economic situations of individuals and populations.



## Hofstadter's letterform problems:

What feature(s) of the letter "A" make(s) it recognizable as an "A" in so many fonts?

What feature(s) of the human brain allow the design to "infect" the brain with the concept of "A"?

