Why Building Animals Is Hard

Wistar Retrospective Symposium
Woburn, Massachusetts

6 June 2007

Paul A. Nelson
Fellow, Discovery Institute
www.discovery.org/csc
Adjunct Professor, MA Program in Science & Religion
Biola University
www.biola.edu/scienceandreligion/

The persistence of a deep problem: "the whole real guts of evolution"

"The whole real guts of evolution – which is, how do you come to have horses and tigers, and things – is outside the mathematical theory."

C.H. Waddington, at the Wistar Symposium (1966)

35 years later...let's hear from Günther Wagner:

"...many important evolutionary phenomena do not result naturally from the current implementation of the neo-Darwinian model. These phenomena comprise patterns and processes of phenotypic evolution, such as...innovation, directionality in evolution and phenotypic stability or homology." (2001, 242)

Euphydyas editha quino

Chlosyne gabbii

(photo credit Biodiversity Research Center of the Californias)

Massimo Pigliucci, last October (2006):

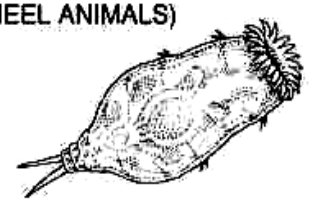
"The Modern Synthesis doesn't cut it because it's got the conceptual tools to tell us how quantitative variation[s] evolve, but not how qualitatively new traits arise."

NSF Workshop on the Origin of Novel Features, Indiana University (10/6-10/8 2006)

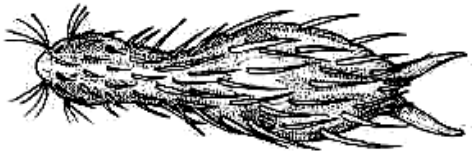
ACANTHOCEPHALA
(SPINY-HEADED WORMS)

d

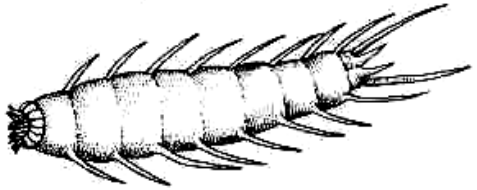
ROTIFERA (WHEEL ANIMALS)



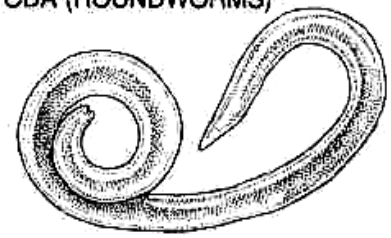
GASTROTRICHA (SCALED WORMS)



KINORHYNCHA (SPINY-SKINNED WORMS)

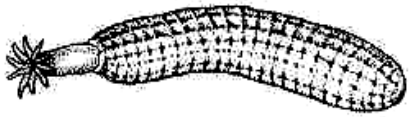


NEMATODA (ROUNDWORMS)

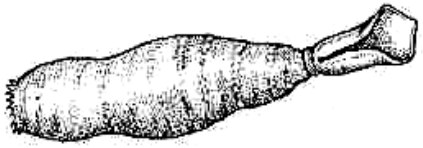


SIPUNCULIDA (PEANUT WORMS)

f

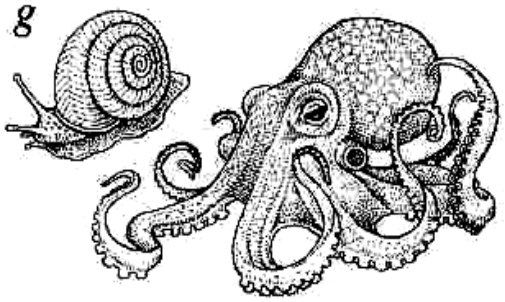


ECHIUROIDEA (SAUSAGE-SHAPED
MARINE WORMS)



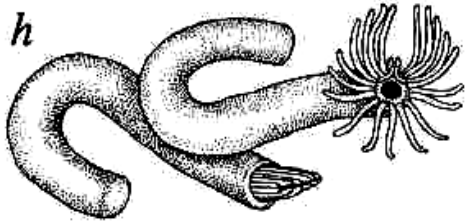
MOLLUSCA (CLAMS, SNAILS,
OCTOPUS, SQUID)

g

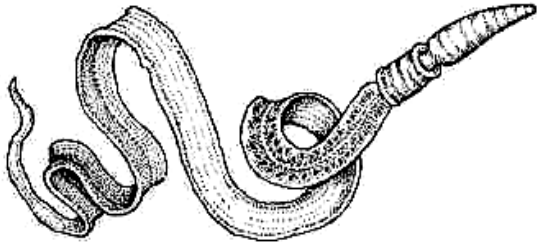


PHORONIDA (HORSESHOE WORMS)

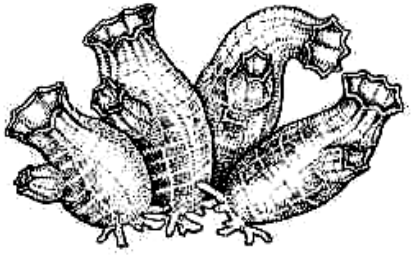
h



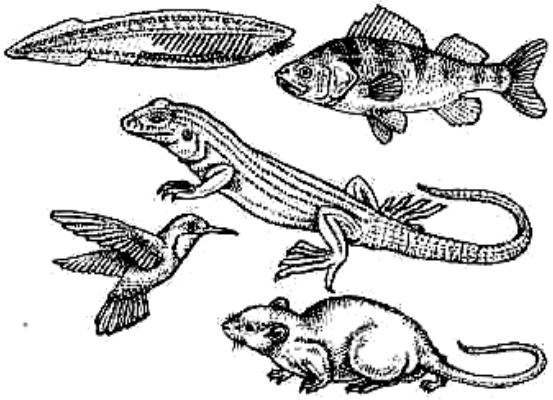
HEMICHORDATA (ACORN WORMS)



UROCHORDATA (SEA SQUIRTS)



CHORDATA (AMPHIOXUS, FISHES,
AMPHIBIANS, REPTILES, BIRDS,
MAMMALS)



Thesis: the essential viscera of neo-Darwinism are missing, and will be forever, because natural selection cannot (*maybe*, in principle) build end-directed causal trajectories of any depth.

Such as metazoan development.

Two theories stemming from Darwin (1859):

1. The common descent of the Metazoa (the animals)

2. Natural selection as the main cause of biological novelty

If, within a species or population, the individuals

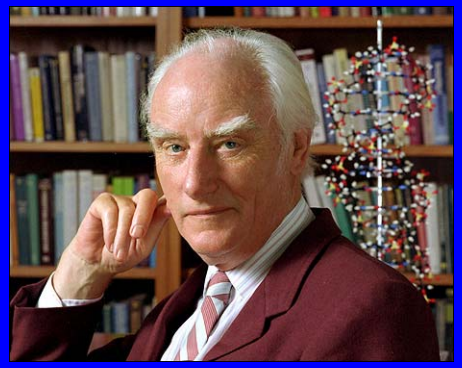
a. vary in some trait q – the condition of **variation**;

b. leave different numbers of offspring in consistent relation to the presence or absence of trait q – the condition of **selection**;

c. transmit trait q faithfully between parents and offspring – the condition of **heredity**;

then the frequency of trait q will differ predictably between the population of all parents and the population of all offspring. (Lewontin 1978; Endler 1986)

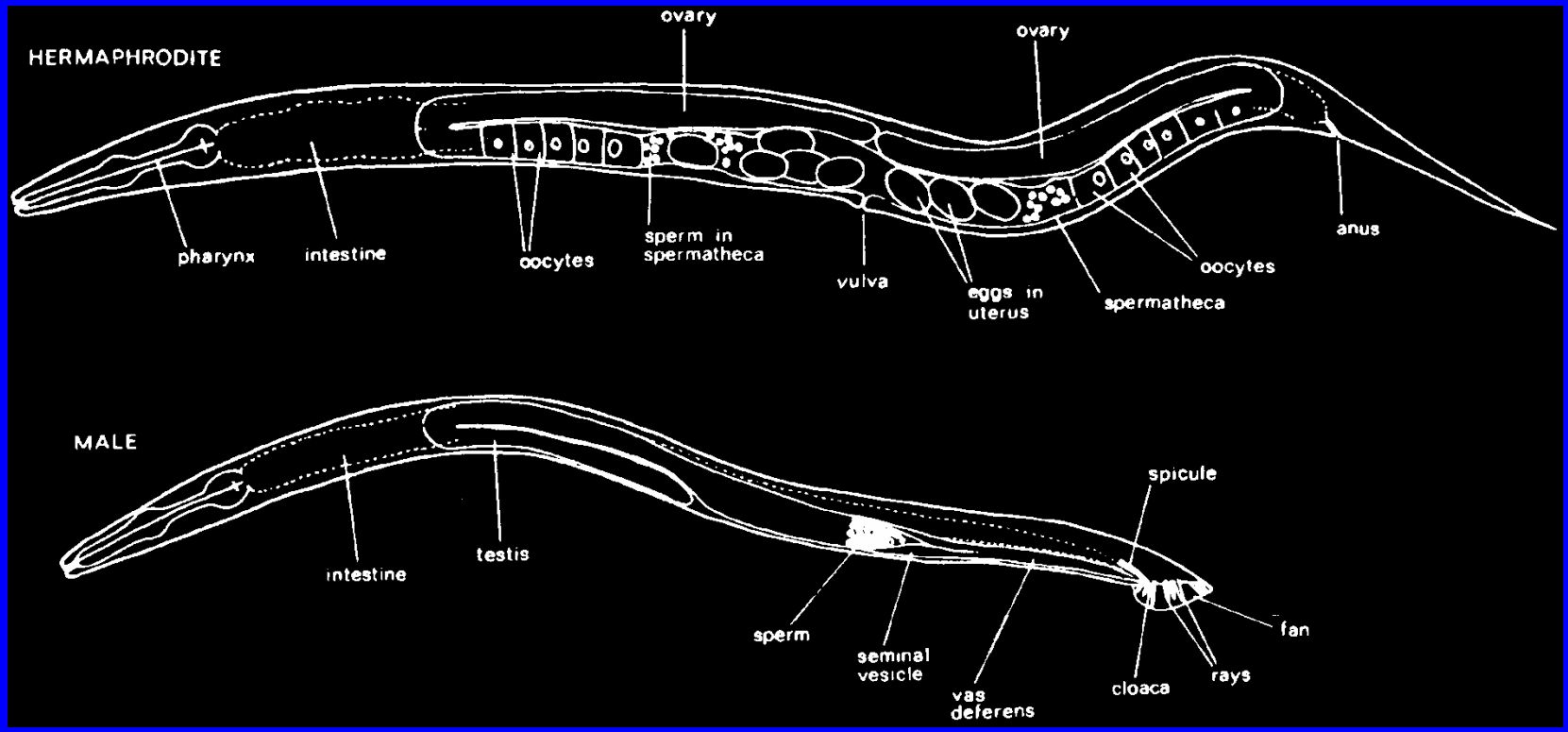
Geneticist Gabriel Dover (1992, 281) on Francis Crick's challenge about evolution:



"At the age of 40 (or thereabouts) I was momentarily reduced to feeling like a 10 year-old novice by Francis Crick in Bronowski's old office at the Salk Institute, where I had gone in the early 1980s to discuss selfish DNA and related concepts."

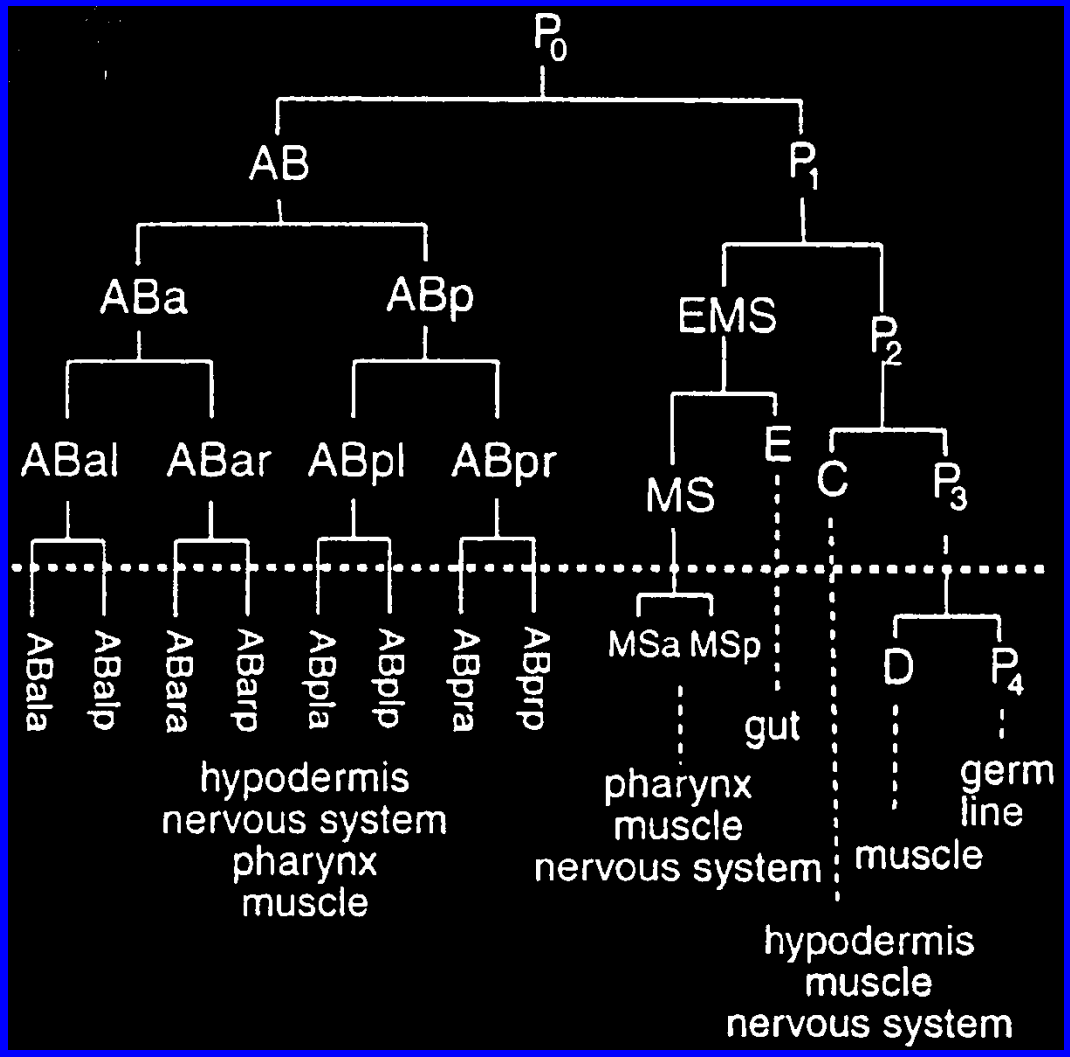
“Crick challenged me with the statement that nothing can be said about evolution until we understand how organisms are put together.”

Adult morphology of *Caenorhabditis elegans*



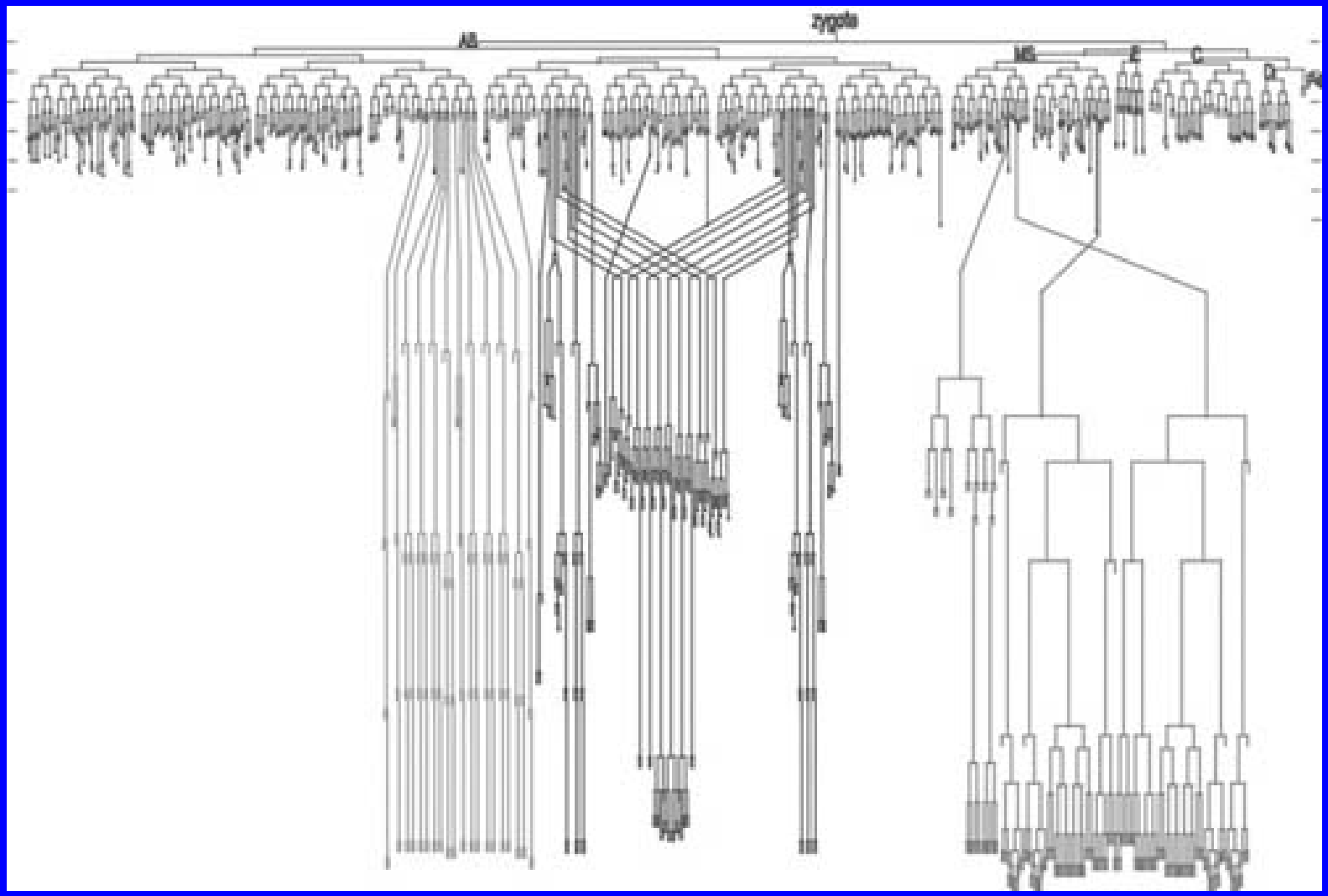
(figure after Hodgkin 1987, 135)

The early cell lineage of *Caenorhabditis elegans*

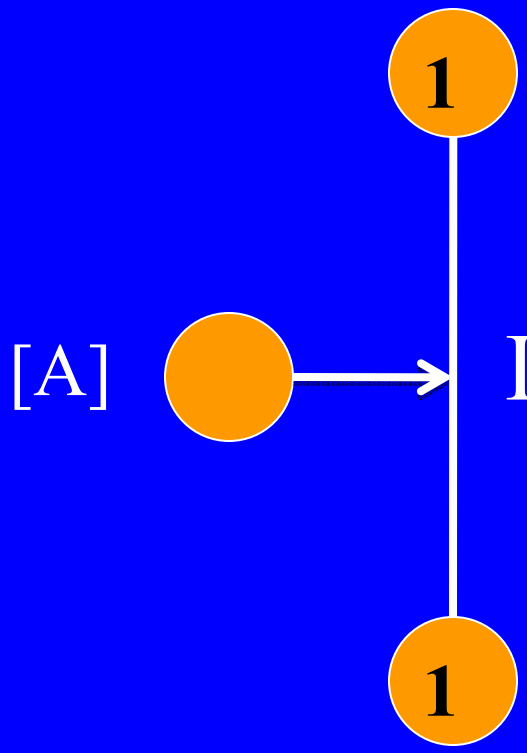


(figure after Schnabel 1997, 342)

The complete cell lineage of *Caenorhabditis elegans*

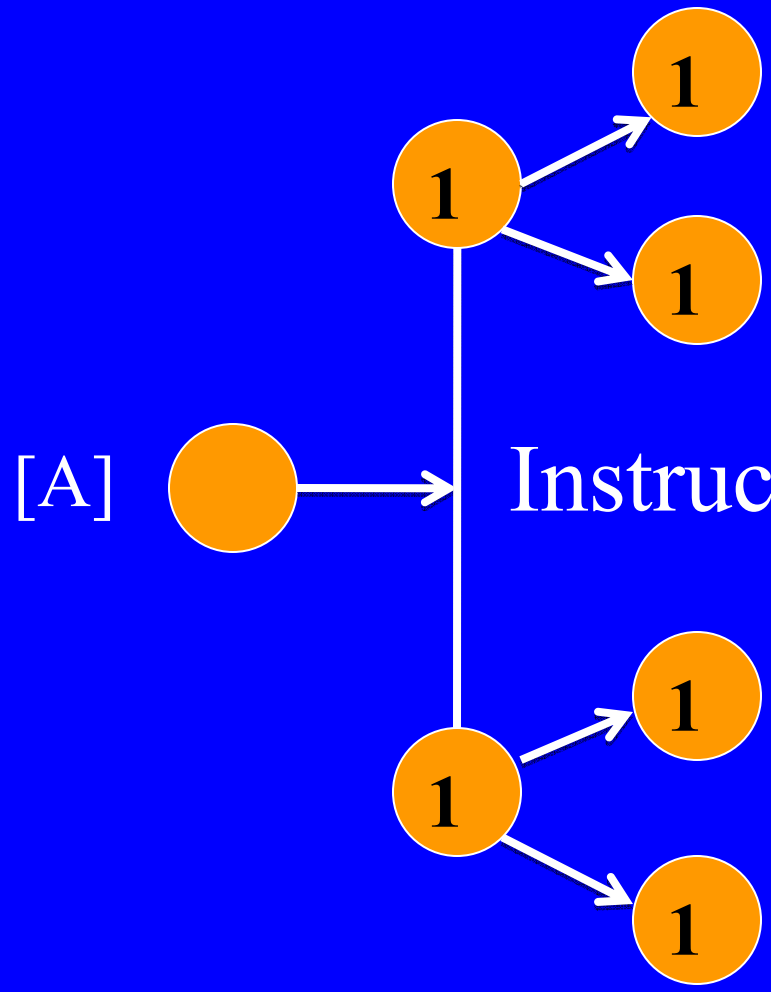


The puzzle of cellular differentiation



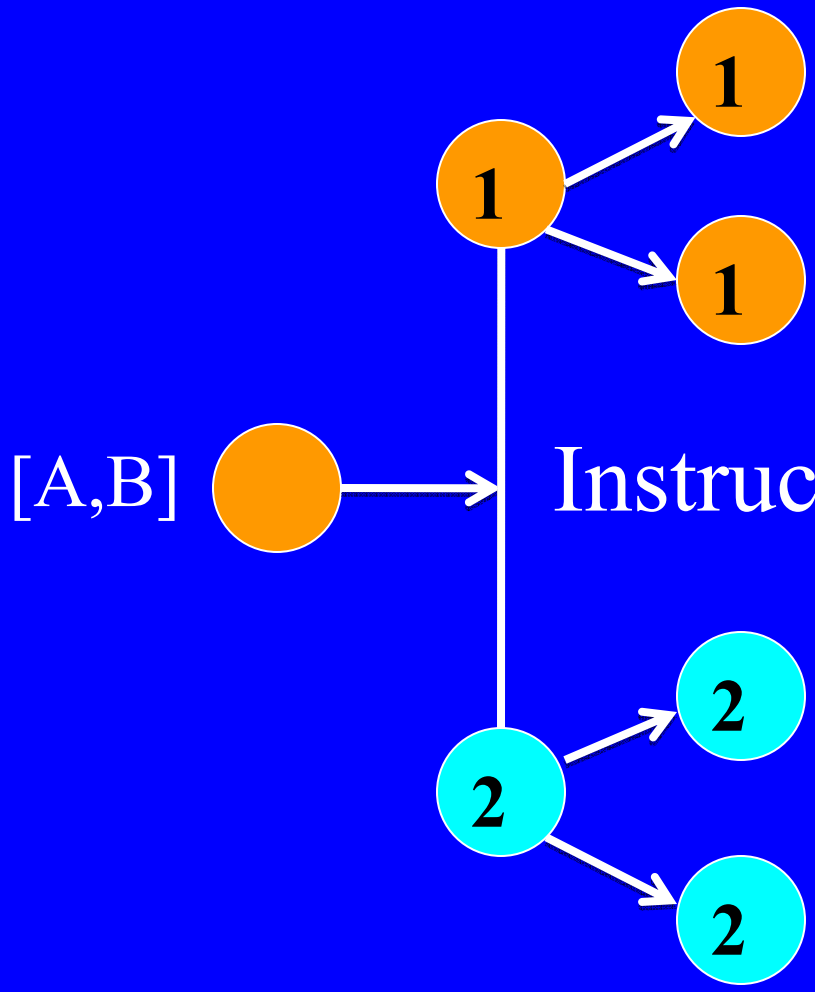
Instruction A: “divide with equivalent daughters”

The puzzle of cellular differentiation



Instruction A: “divide with equivalent daughters”

The puzzle of cellular differentiation



Instructions A, B: “divide; with ***nonequivalent*** daughters”

If, within a species or population, the individuals

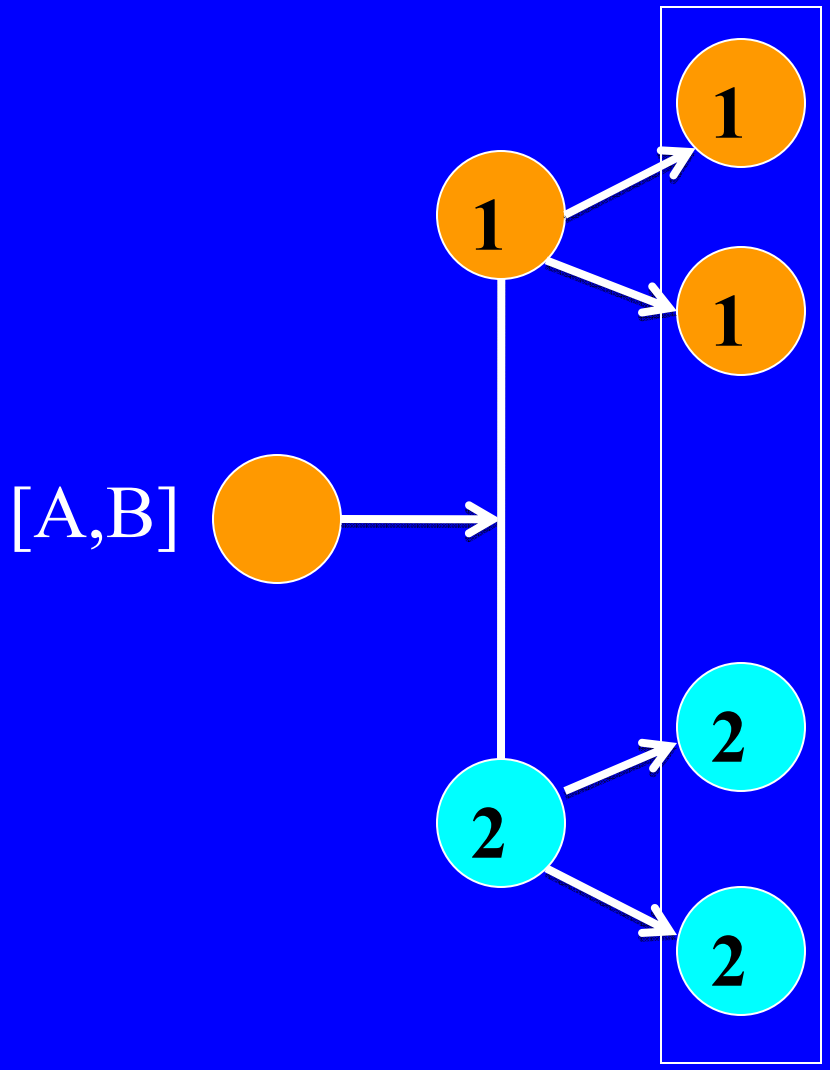
a. vary in some trait q – the condition of **variation**;

b. leave different numbers of offspring in consistent relation to the presence or absence of trait q – the condition of **selection**;

c. transmit trait q faithfully between parents and offspring – the condition of **heredity**;

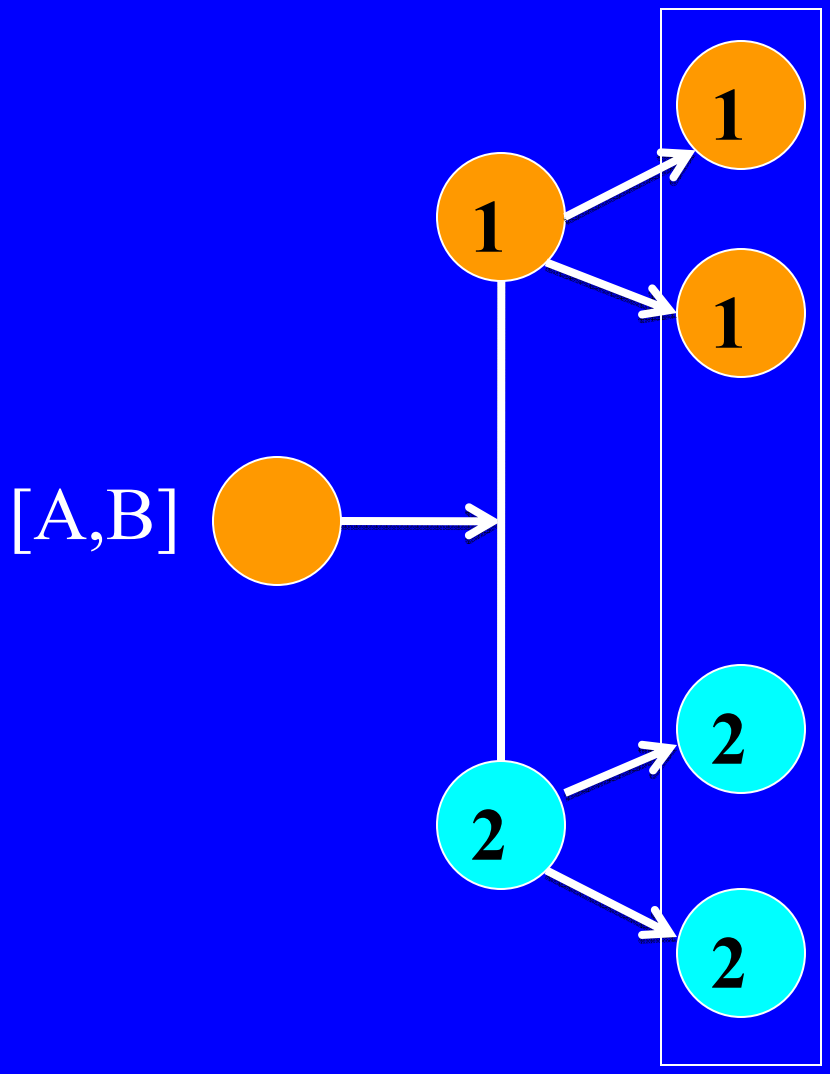
then the frequency of trait q will differ predictably between the population of all parents and the population of all offspring. (Lewontin 1978; Endler 1986)

OK, now we need to *reproduce* this lineage.



That is, we want one (or more) cells in the organism to give rise to another, separate iteration of the whole lineage.

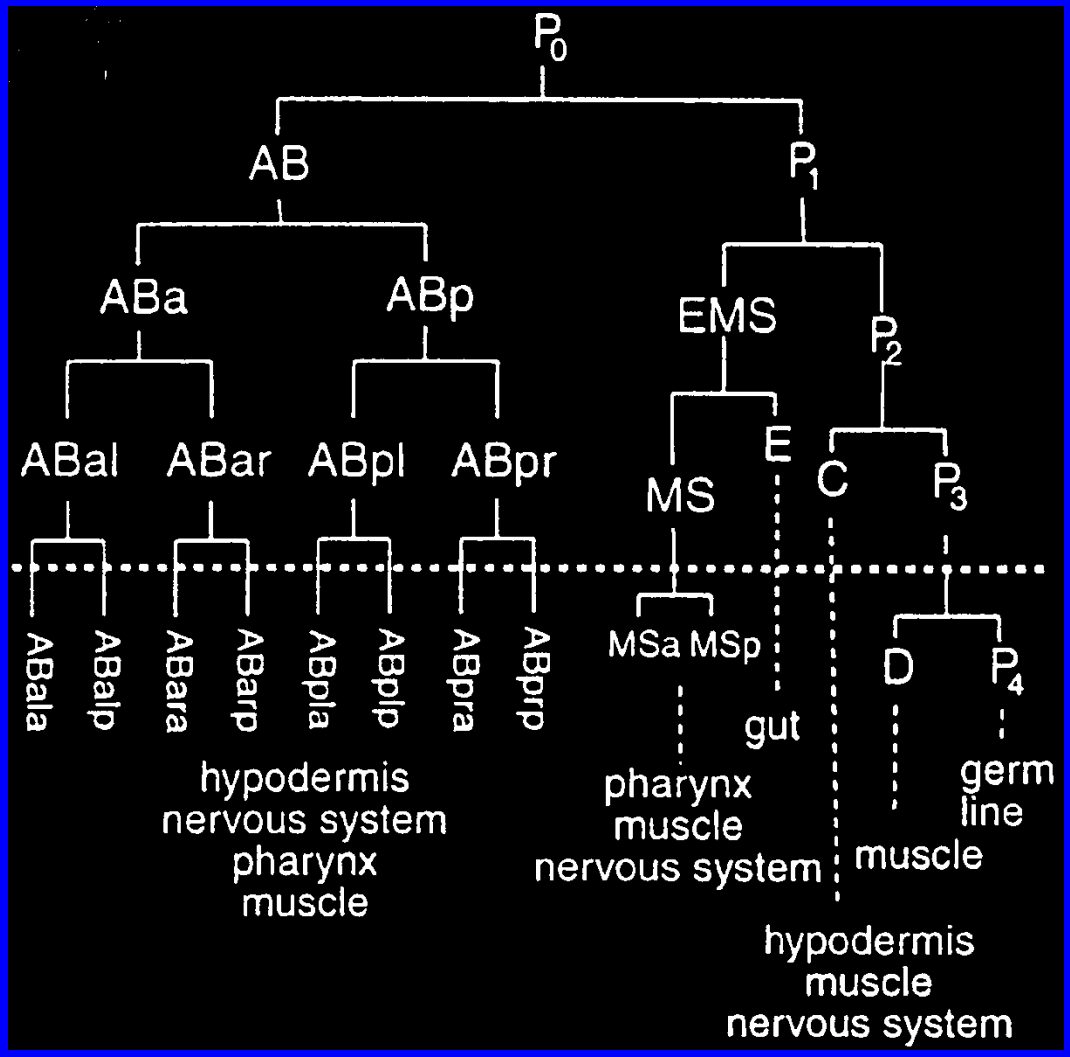
What's the obvious problem?



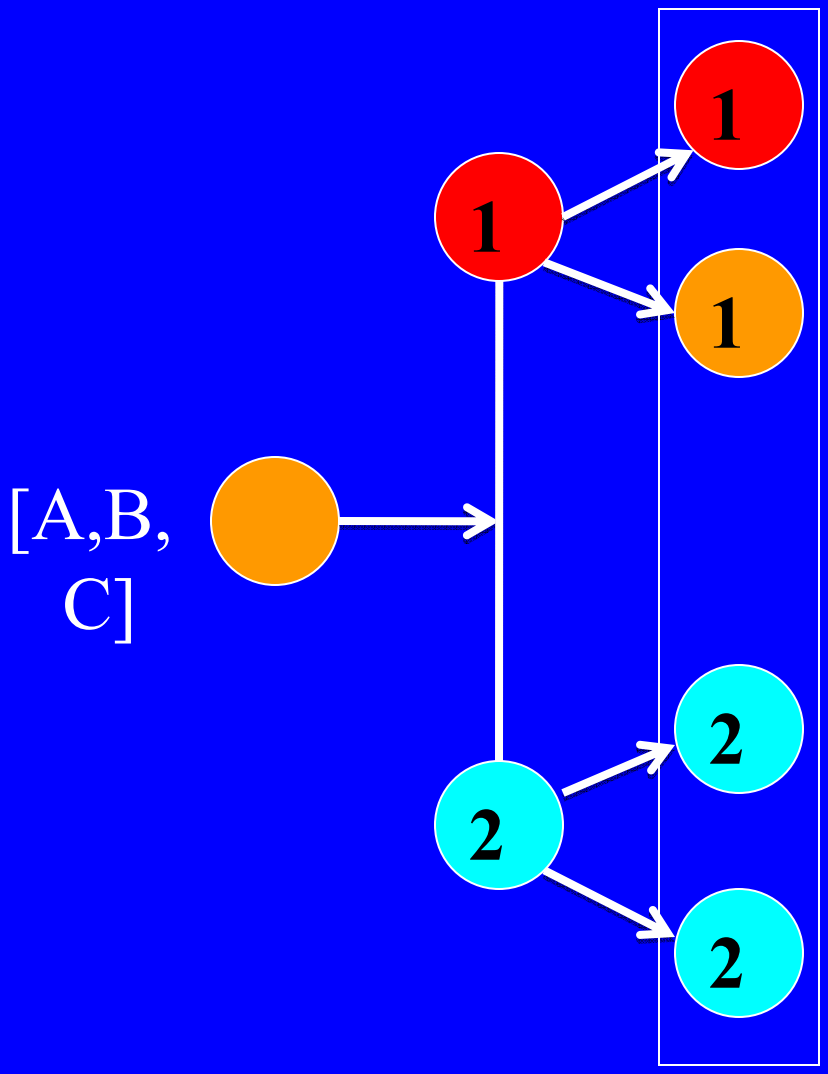
Which cell is keeping track of the instruction set [A,B] for the whole lineage?

This is *the functional reason* animals need something like a germ line; call that instruction C.

The early cell lineage of *Caenorhabditis elegans*



(figure after Schnabel 1997, 342)



To build an organism with *four* cells of *three* differentiated cell types, and to reproduce its lineage, at least 3 instructions are necessary in the starting cell, before development begins.

Rupert Riedl (1978, 219-20) on the paradox of "teleological evolution":

"If these 'diagrams of organisms' represented functional ancestors they would prove the paradox of teleological evolution. For their parts always strive towards functions, without being able to possess them during their formation."

Rupert Riedl (1978, 219-20) on the paradox of "teleological evolution":

"Like orderly piles of bricks or building timber, they do not yet have a function. In the same way scaffolding may indicate the shape of the future building, though it would fail any test of thermal or noise insulation, not to mention habitability."