### IMPORTING THE HOMOLOGY CONCEPT FROM EVOLUTIONARY BIOLOGY INTO DEVELOPMENTAL PSYCHOLOGY

Workshop: Homology in Developmental Psychology Dalhousie University, Halifax, NS, Canada August 16, 2011

## WHAT IS HOMOLOGY?





## A CATALOGUE OF TYPES OF HOMOLOGY

## LEVELS OF ANALYSIS

- A non-exhaustive list:
  - I. Morphological homology (bodily structures)
  - II. Molecular homology (DNA)
  - III. Behavioral homology
  - IV. Developmental homology (processes)









### I) TAXIC/SPECIAL HOMOLOGY (MORPHOLOGY, CONTEMPORANEOUS)









## I) TAXIC/SPECIAL HOMOLOGY (MORPHOLOGY, CONTEMPORANEOUS)



## I) TAXIC/SPECIAL HOMOLOGY (MORPHOLOGY, NONCONTEMPORANEOUS)



### HOMOLOGY VERSUS ANALOGY



## I) SERIAL HOMOLOGY (MORPHOLOGY, CONVENTIONAL)



### I) SERIAL HOMOLOGY (UNCONVENTIONAL, CONTEMPORANEOUS)



## I) SERIAL HOMOLOGY (UNCONVENTIONAL, NONCONTEMPORANEOUS)





#### MALE GONADAL DEVELOPMENT

### FEMALE GONADAL DEVELOPMENT

## I) SERIAL HOMOLOGY (UNCONVENTIONAL, NONCONTEMPORANEOUS)



## I) SERIAL HOMOLOGY (UNCONVENTIONAL, CONTINUOUS)





### II) MOLECULAR HOMOLOGY (DNA) ORTHOLOGUES (TAXIC-STYLE)



MSEGVGTFRMVPEEEQELRAQLEQLTTKDHGPVFGPCSQLPRHTLQKAKDELNEREETREEAVRELQEMVQAQAASGEELAVAVAERVQEKDSGFFLRFIRARKFNVGRA 110 MSDGVGTFRMVPEEEQELRAQLEQLTTKDHGPVFGPCSQLPRHTLQKAKDELNEKEETREEAVRELQELVQAQAASGEELALAVAERVQARDSAFLLRFIRARKFDVGRA 110 MAVVSGTFRMVSEEEOALRAKLEHLTVKDHGPVFEASTKVPDHTMOKAKDELNETDEKRTSAVKELRGIIKEKAETGDELAKGVODTFGEKPDGVLVRFIRARKYDVNRA 110 -MAATGSFRMVSEEEQALRAKLEHLTVKDHGPVYGPCMKLPDHTKQKAKDELNETDEKRASAIKELRAMIKDKAGQGDEVAKTVQDKFGKEPDSLLLRFIRARKFDVARA 109 \*:\*\*\*\* \*\*\*\* \*\*\*:\*\*:\*\* \*\*\*\*\*\*: .. .:\* \*\* \*\*\*\*\*\*\* :\*.\* .\*.:\*\*: ::: :\* \*:\*:\* \* : .

Homo sapiens Mus musculus Danio rerio Cralbp a Danio rerio Cralbp b

> YELLRGYVNFRLQYPELFDSLSPEAVRCTIEAGYPGVLSSRDKYGRVVMLFNIENWQSQEITFDEILQAYCFILEKLLENEETQINGFCIIENFKGFTMQQAASLRTSDL 220 YELLKGYVNFRLQYPELFDSLSMEALRCTIEAGYPGVLSSRDKYGRVVMLFNIENWHCEEVTFDEILQAYCFILEKLLENEETQINGFCIVENFKGFTMQQAAGLRPSDL 220 YELMKGYVRFRRDYPELFENLTPEAVRSTIEAGYPGILSSRDKYGRVVLLFNIENWDYEEITFDEILRAYCVILEKLLENEETQINGFCIIENFKGFTMQQASGIKPTEL 220 HELMKGYVRFRRDYPELFENLTPEAVRSTIEAGYPRILSTRDKNGRVVLLFNIDNWDLEEVTFDETLRAYCVILEKLLENEETQINGFVLIENFKGFTMQHASGIKHTEL 219

Homo sapiens Mus musculus Danio rerio Cralbp a Danio rerio Cralbp b

Homo sapiens Mus musculus

DMLQDSFPARFKAIHFIHQPWYFTTTYNVVKPFLKSKLLERVFVHGDDLSGFYQEIDENILPSDFGGTLPKYDGKAVAEQLFGPQAQAENTAF 317 KKMVDMLQDSFPARFKAIHFIHQPWYFTTTYNVVKPFLKNKLLQRVFVHGDDLDGFFQEIDENILPADFGGTLPKYDGKVVAEQLFGPRAEVENTAL 317 KKMVDMLQDSFPARFKAVHFIHQPWYFTTTYNVVKPLMKSKLLERVFVHGDDLENYFKEFDAEILPSDFDGKGSKYDGKITAAHLFD-----307 KKMVDMLQDSFPARFKAVHVIHQPWYFTTTYNVVKPFMKSKLLERVFVHGDELDGYLRDFGAEILPPDFDGTGPACDGRETAIKLFG---SEDTAL 312 \*\*: \*. :\*\* . . \*.\*\*\*

Danio rerio Cralbp a Danio rerio Cralbp b

PROTEIN SEQUENCE FOR CELLULAR RETINALDEHYDE BINDING PROTEIN

### II) MOLECULAR HOMOLOGY (DNA) PARALOGUES (SERIAL-STYLE)



### ORTHOLOGS AND PARALOGS IN EVOLUTION



### II) MOLECULAR HOMOLOGY (DNA) XENOLOGUES (NO MORPHOLOGICAL COUNTERPART)



## III) BEHAVIORAL HOMOLOGY



### III) BEHAVIORAL HOMOLOGY

#### Chimpanzee

J Nonverbal Behav (2007) 31:1-20

Low wrinkled forehead Textured brow ridge

> Nasal channel Subnasal furrow

Prognathic lower face Vertical lip wrinkles Slight lip eversion



Common

FRONTALIS [1, 2]
CORRUGATOR SUPERCILLI [4]

Glabellar Nasion Eye-fold cover Lower eye-lid furrow Infra-orbital triangle



Human

Large forehead Eye brow hair Scleral contrast Nasal bridge

Nasiolabial furrow Cheek fat

0.000

Philtrum Everted lipsBony chin boss

#### Fig. 1 Facial morphology in humans and chimpanzees



*Figure 1.* Comparison of the location, structure and relative size of facial muscles in human and chimpanzee. Numbers shown are human FACS action units (Ekman et al., 2002a). Where the specific muscle is not shown, the general area is circled. Muscles not shown in the central table reported only in human, but see Burrows, Waller, Parr and Bonar (2006) (Zi = Zygomatic Minor, R = Risorius). Human diagram adapted from Hager (2000) and chimpanzee dissection diagram adapted from Pellatt (1979b). All images used with permission.

# III) BEHAVIORAL HOMOLOGY



## INDEPENDENCE OF HOMOLOGY AT DIFFERENT LEVELS OF ANALYSIS

## HOMOLOGY INDEPENDENCE, MOLECULAR





## HOMOLOGY INDEPENDENCE, NEURAL



## HOMOLOGY INDEPENDENCE, PROCESSES





## IDENTIFYING HOMOLOGY

## HOW BIOLOGISTS IDENTIFY HOMOLOGY

- Remane's (1952) criteria (taxic, serial, behavioral, process)
  - 1. Position (physical or temporal)
  - 2. Special quality
  - **3**. Connection to evolutionary—or for us, developmental—intermediates

### K. LORENZ (1958), SCIENTIFIC AMERICAN



"Anyone who has watched a dog scratch its jaw or a bird preen its head feathers can attest to the fact that they do so in the same way. The dog props itself on the tripod formed by its haunches and two forelegs and reaches a hindleg forward in front of its shoulder. Now the odd fact is that most birds (as well as virtually all mammals and reptiles) scratch with precisely the same motion! A bird also scratches with a hindlimb (that is, its claw), and in doing so it lowers its wing and reaches its claw forward in front of its shoulder. One might think that it would be simpler for the bird to move its claw directly to its head without moving its wing, which lies folded out of the way on its back. I do not see how to explain this clumsy action unless we admit that it is inborn. Before the bird can scratch, it must reconstruct the old spatial relationship of the limbs of the fourlegged common ancestor which it shares with mammals."

### CHARACTERS VERSUS STATES: CHARACTERS



## CHARACTERS VERSUS STATES: STATES



## CHARACTERS VERSUS STATES: STATES



## HOW CAN HOMOLOGY HELP DEVELOPMENTAL PSYCHOLOGISTS?

## QUOTING MATTHEN (2007)









### AVOIDING POTENTIALLY FALSE ASSUMPTIONS



## HOMOLOGIES AS NATURAL KINDS



# PROBLEMS FOR US TO OVERCOME

## WHAT'S NOT A HOMOLOGY?







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