Nematode Tree-of-Life Project

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Nemas, nemas everywhere

"..if all matter in the universe except nematodes were swept away, our world would still be dimly recognizable… we would find its mountains, hills, valleys, rivers, lakes and oceans represented by a thin film of nematodes."

Cobb, N.A. (1914) *USDA yearbook*, pp. 457-490.

Objectives

- Overall goal
  - Evolutionary framework for Nematoda
- Specific aims
  - SSU rDNA sequences for 1000 representatives
  - Other orthologous loci for resolution of basal lineages
  - Integrate molecular, morphological, and meta-data
  - Present all data in an online database

Workshops

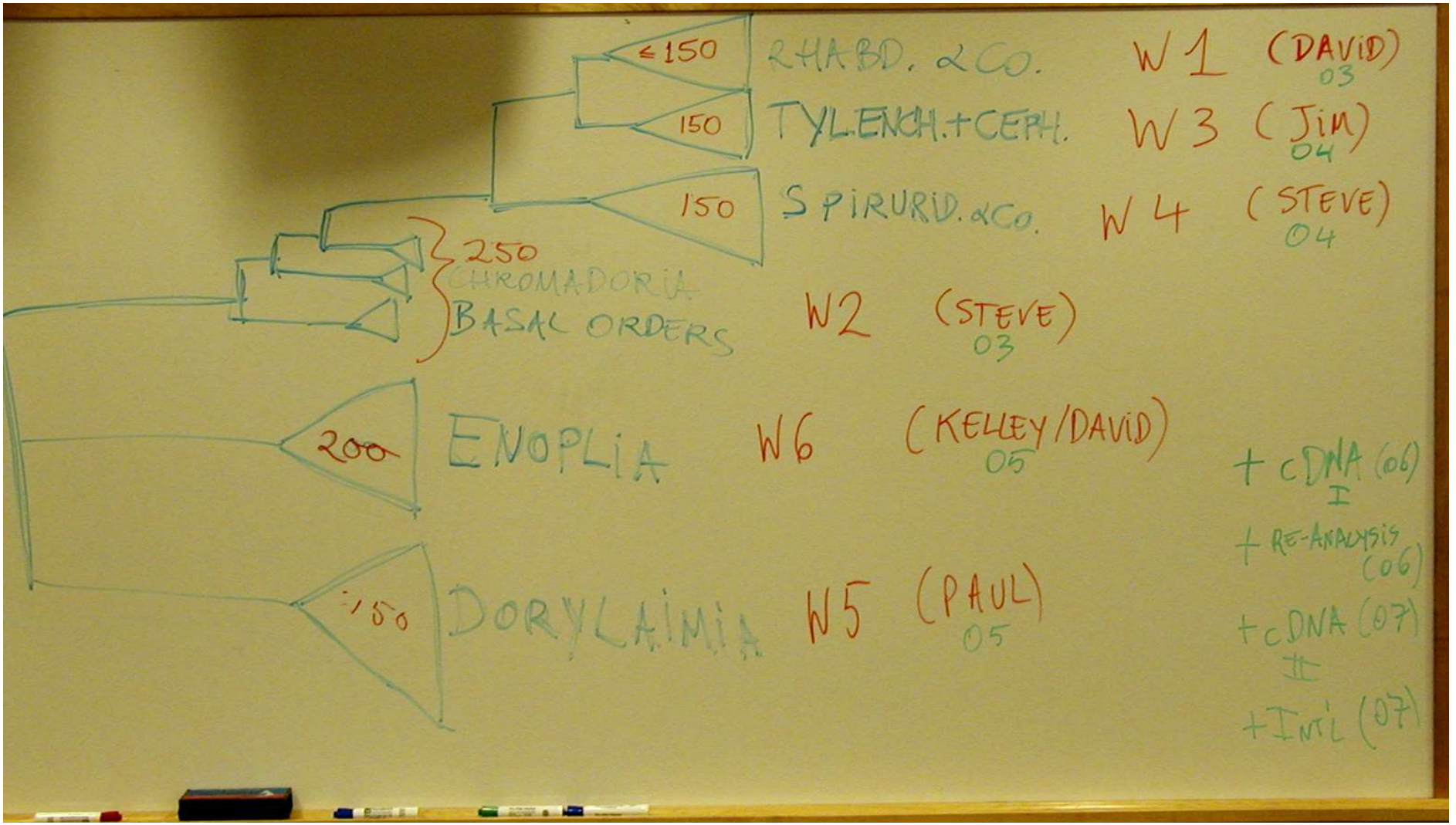
International expertise to:

1. Choose phylogenetically representative taxa

2. Obtain material for molecular & morphological analyses

3. Develop of morphological & ontogenetic character sets

How many taxa?



Which taxa?

Paradox: how to get "phylogenetic representation" without *a priori* knowledge of phylogeny?

- Traditional taxa (families, genera)
- Prior morphological phylogenies
- Prior molecular phylogenies
- Other features
  - Evolutionary novelty
  - Model systems

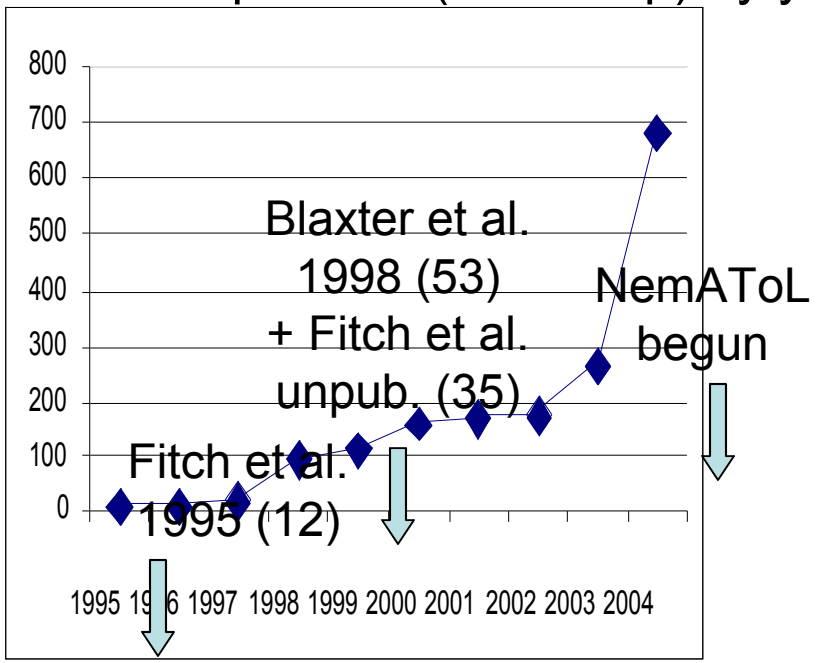
Part of taxon list for Clade V

SSU rDNA	ITS rDNA	Morphology	species	strain #	source
Ã	Ã		*Cephaloboides nidrosiensis*	DF5075	Fitch nematode zoo
Ã	Ã		*Pellioditis buetschlii*		cow dung, frozen
Ã			*Oscheius guentheri*	SB133	Fitch freezer
Ã	Ã		*Oscheius tipulae*	CEW1	Fitch nematode zoo
Ã	~ Ã		*Oscheius dolichuroides*	DF5018	Fitch nematode zoo
Ã			*Oscheius insectivora*	SB169	Fitch nematode zoo
Ã	Ã		*Oscheius myriophila*	DF5020/EM435	Fitch nematode zoo
Ã			*Pellioditis* sp. (fiji)	PS1191	Fitch nematode zoo
Ã	Ã		*Rhabditis blumi*	D5010	Fitch nematode zoo
Ã	~ Ã		*Rhabditis* sl. sp.	SB347	Fitch nematode zoo
Ã			*Cephaloboides* sp.	SB227	cactus rot
X			*Diploscapteroides*		coal mine in Switzerland
Ã	Ã	Ã	*Rhabditella axei*	DF5006	Fitch nematode zoo
Ã	Ã		*Pellioditis mediterranea*	DF5071/SB173	DF 7071 in Fitch zoo
Ã			*Pellioditis* cf. *neopapillosa*	EM434	Fitch freezer
Ã	Ã		*Rhabditis brassicae*	SB193	Fitch nematode zoo
Ã	Ã		*Pellioditis typica*	DF5025	Fitch nematode zoo
Ã	Ã		*Choriorhabditis longicaudata*		cow dung, frozen
Ã	Ã		*Cruznema tripartita*	SB202	Fitch nematode zoo
Ã	Ã		*Choriorhabditis dudichi*	SB122	Fitch nematode zoo
Ã			*Choriorhabditis cristata*	SB300	Fitch nematode zoo
Ã	Ã	Ã	*Caenorhabditis elegans*	N2	
Ã	Ã	Ã	*Caenorhabditis japonica*	SB339	Fitch nematode zoo
Ã	Ã	Ã	*Caenorhabditis* sp.	PS1010	Fitch nematode zoo
Ã	Ã	Ã	*Caenorhabditis* sp.	DF5070	Fitch nematode zoo
Ã	Ã	Ã	*Caenorhabditis drosophilae*	DF5077	Fitch nematode zoo
Ã	Ã	Ã	*Caenorhabditis* sp.	SB341	Fitch nematode zoo
Ã	Ã		*Prodontorhabditis wirthi*	DF5074	Fitch nematode zoo
Ã	Ã		*Protorhabditis* sp.	DF5055	Fitch nematode zoo
Ã	~ Ã		*Protorhabditis* sp.	JB122	Fitch nematode zoo
Ã	~ Ã		*Diploscapter* sp.	JU359	Fitch nematode zoo
Ã	Ã		*Rhabditoides longispina*		cow dung, frozen
Ã	Ã	Ã	*Pelodera strongyloides*	DF5022	Fitch nematode zoo
Ã	Ã	Ã	*Pelodera teres*	EM437	Fitch nematode zoo
Ã	Ã	Ã	*Pelodera cylindrica*	SB351	Fitch nematode zoo
Ã	Ã	Ã	*Teratorhabditis palmarum*	DF5019	Fitch nematode zoo
Ã	Ã	Ã	*Mesorhabditis* sp.	PS1179	Fitch nematode zoo
Ã	Ã	Ã	*Mesorhabditis longespiculosa*	DF5017	Fitch nematode zoo
Ã	Ã	Ã	*Parasitorhabditis obtusa*		bark beetles
Ã	Ã	Ã	*Crustorhabditis transita*	SB125	
Ã	Ã	Ã	*Distolabrellus veechi*	DF5024	Fitch nematode zoo
Ã	Ã	Ã	*Rhabdioides regina*	DF5012	Fitch nematode zoo
Ã			*Rhabditis* sl. sp.	PDL15	Fitch nematode zoo
Ã	Ã	Ã	*Poikilolaimus oxycerca*	SB200	Fitch nematode zoo
Ã	Ã	Ã	*Rhabditoides inermis*	SB328/SB310	SB328 in Fitch zoo
Ã	Ã		*Panagrellus redivivus*	PS1163	for workshop 2!

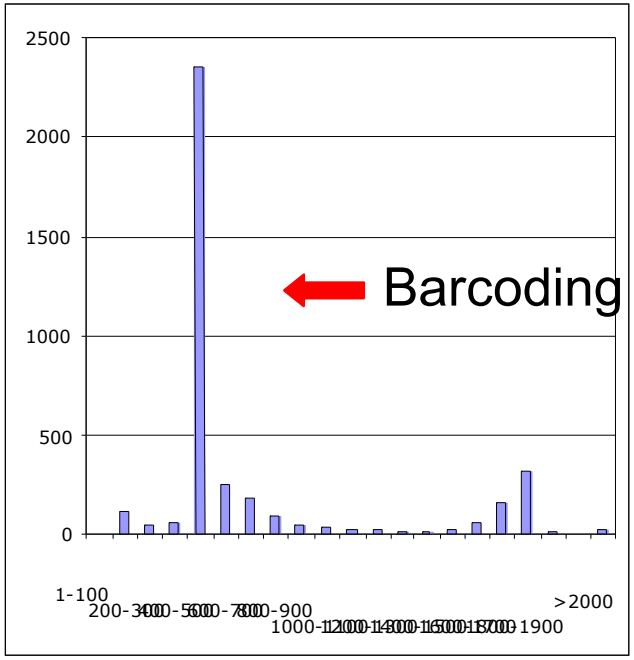
SSU rDNA	ITS rDNA	Morphology	species	strain #	source
Ã	Ã	Ã	*Rhabditoides inermiformis*	SB158/SB303	SB303 in Fitch zoo
Ã	Ã		*Acrostichus halicti*	JB120	Fitch nematode zoo
X			*Butlerius*		compost
X			*Cephalobium*		crickets
Ã	Ã		*Demaniella* sp.	SB318	Fitch nematode zoo
X	X		*Diplogaster rivalis?*		aquatic
~ Ã	Ã		*Diplogasteriana schneideri*		frozen from elm in Central park
Ã	X		*Diplogasteroides magnus*	PDL8	Fitch nematode zoo
Ã			*Diplogastrellus cerus*	SB223	Fitch nematode zoo
Ã	Ã		*Diplogastrellus indicus*	SB126	Fitch nematode zoo
Ã			*Fictor faecalis*		cow dung
X			*Goffartia*		Heterocerus
Ã	X		*Goodeyus ulmi*	PDL20	
X			*Heteropleuronema*		rain forest soil
Ã	Ã		*Koerneria* sp.	RS113	Fitch zoo (SB110=synonym)
X			*Longibucca*		bull frogs in Brazil
X	X		*Mehdinema*		crickets
X			*Micoletzkya*		bark beetles
Ã~	Ã		*Mononchoides*		
Ã~	Ã		*Neodiplogaster tropica*		Sudhaus lab
Ã	Ã		*Odontopharynx longicaudata*		insect associated
Ã~	Ã		*Oigolaimella* sp.		Sudhaus lab
Ã	Ã		*Parasitodiplogaster*		Fig wasps
X			*Paroigolaimella*		dung
Ã	Ã		*Pristionchus pacificus*	PS312	Fitch nematode zoo
Ã	Ã~		*Pseudodiplogasteroides* sp.	SB257	Fitch nematode zoo
Ã	Ã		*Rhabditidoides* sp.	SB304	Fitch nematode zoo
Ã	Ã		*Sachsia*		cow dung
Ã	Ã~		*Tylopharynx foetida*		cow dung, frozen
X			*Diplenteron*		sand dunes
Ã	Ã~		*Bunonema* sp.		Fitch nematode zoo
Ã			*Cuticonema vivipara*		Fitch nematode zoo
Ã			*Brevibucca* sp.		Fitch nematode zoo
Ã	X		*Myolaimus* sp.	PDL9	De Ley, Sudhaus lab has PDL23
X			*Matthesonema*		hermit crabs
X			*Stomachorhabditis*		rain forest soil
X			*Carabonema*		carabids
X			*Agfa*		snails
X			*Rhabditonema*		rotten wood
X			*Rhabpanus*		termites
X			*Pterygorhabditis*		
X			*Rhodonema*		rotten wood
X			*Aenigmenchus*		rain forest soil
X			*Rhabditolaimus*		insects in rotten palm, banana
X			*Oryctonema*		scarab beetles
Ã	Ã		*Heterorhabditis bacteriophora*		

Nematode rDNA in databases

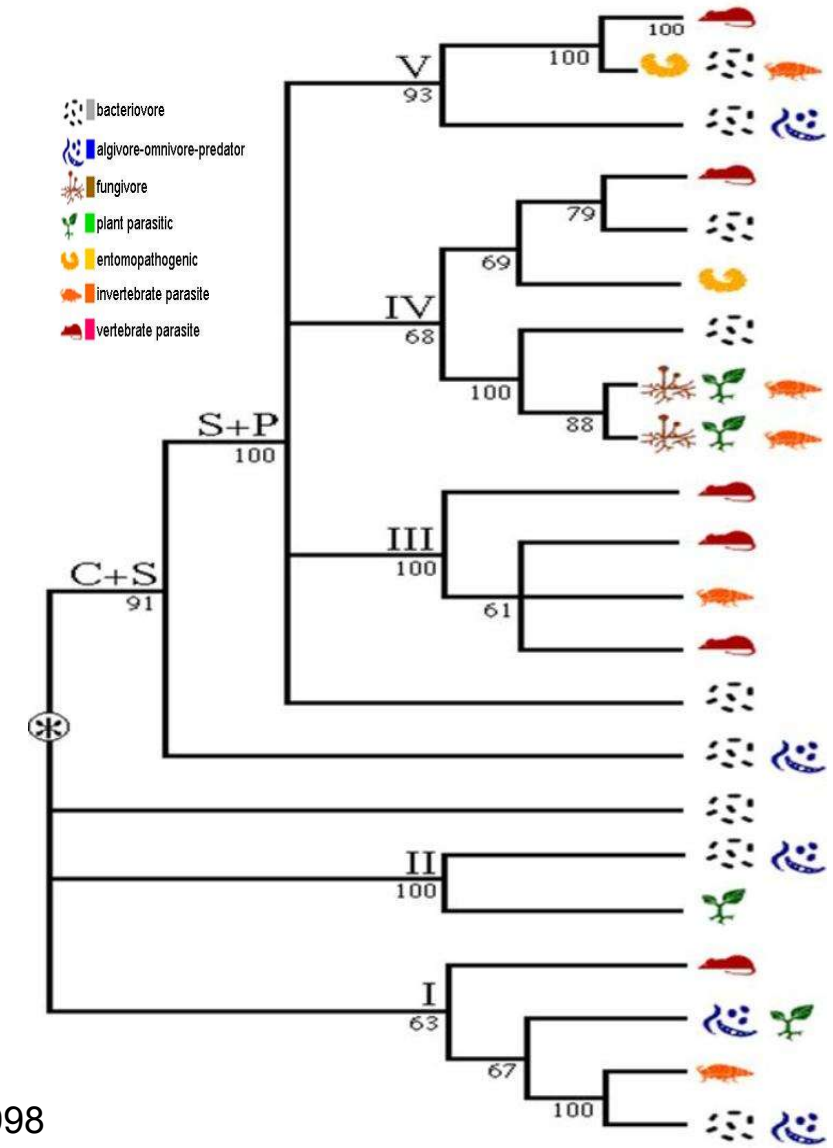
SSU sequences (>1500 bp) by year



SSU sequence database



Choosing additional orthologous loci



Genome sequences

Caenorhabditis elegans
Caenorhabditis briggsae
Caenorhabditis remanei
Caenorhabditis sp.
Caenorhabditis japonica
Pristionchus pacificus

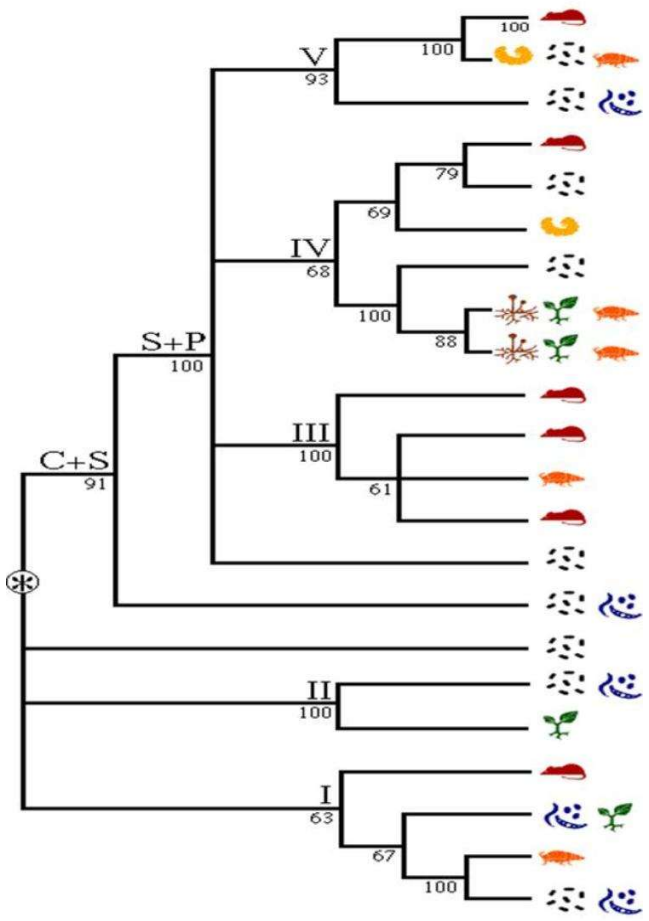
Meloidoigyne hapla

Brugia malayi

Trichinella spiralis

Blaxter et al. 1998

Large-scale cDNA sequencing

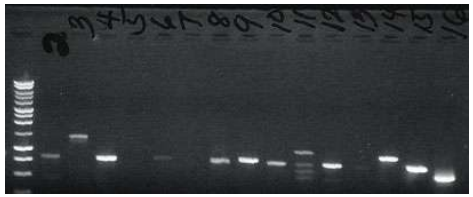


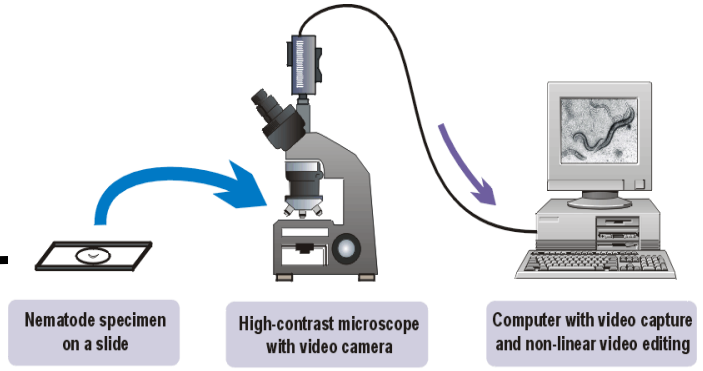
Caenorhabditis elegans	V	215,200	96,850	1, 2, 11
Ascaris suum	III	39,242	426	2, 3, 6
Brugia malayi	III	26,216	18,449	3, 4, 5
Haemonchus contortus	V	21,967	552	3, 6, 9, 10
Heterodera glycines	IVB	20,114	366	2
Meloidogyne hapla	IVB	16,305	38	2
Onchocerca volvulus	III	14,974	791	5, 2
Strongyloides ratti	IVA	14,761	23	2
Meloidogyne incognita	IVB	14,081	239	2, 7
Meloidogyne chitwoodi	IVB	12,218	38	2
Strongyloides stercoralis	IVA	11,392	55	2
Trichinella spiralis	I	10,767	162	2
Ancylostoma ceylanicum	V	10,651	73	2
Ancylostoma caninum	V	9,331	112	2
Pristionchus pacificus	V	8,818	16	2
Parastrongyloides trichosuri	IVA	7,963	3	2
Ostertagia ostertagi	V	7,009	189	2, 3, 6
Meloidogyne javanica	IVB	6,861	55	2
Globodera rostochiensis	IVB	6,934	152	4, 7, 8
Meloidogyne arenaria	IVB	5,018	49	2
Toxocara canis	III	4,889	86	2, 3
Necator americanus	V	4,766	168	3, 6
Teladorsagia circumcincta	V	4,313	125	3, 6
Dirofilaria immitis	III	4,005	170	2
Trichuris vulpis	I	3,083	1	2
Trichuris muris	I	2,716	315	3, 6
Heterodera schachtii	IVB	2,818	26	2
Caenorhabditis briggsae	V	2,424	1,151	2
Wuchereria bancrofti	III	2,166	77	5
Pratylenchus penetrans	IVB	1,928	21	2
Globodera pallida	IVB	1,892	66	12
Ascaris lumbricoides	III	1,822	138	3
Nippostrongylus brasiliensis	V	1,234	37	3
Litomosoides sigmodontis	III	873	33	3
Zeldia punctata	IVB	391	5	2
Onchocerca ochengi	III	60	13	5
Meloidogyne paranaensis	IVB	Pending	0	2
Total Sequences		518,121	121,068	
Total Non- *Caenorhabditis*		300,497	23,067	

Modified from www.nematode.net

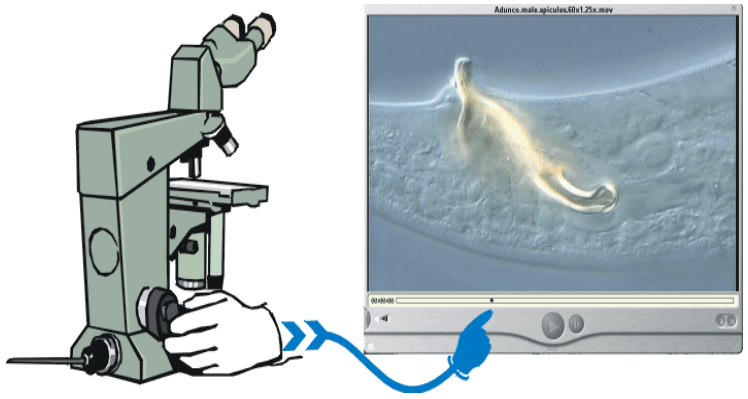
Multi-focal digital vouchers

Molecular analysis of individuals after imaging





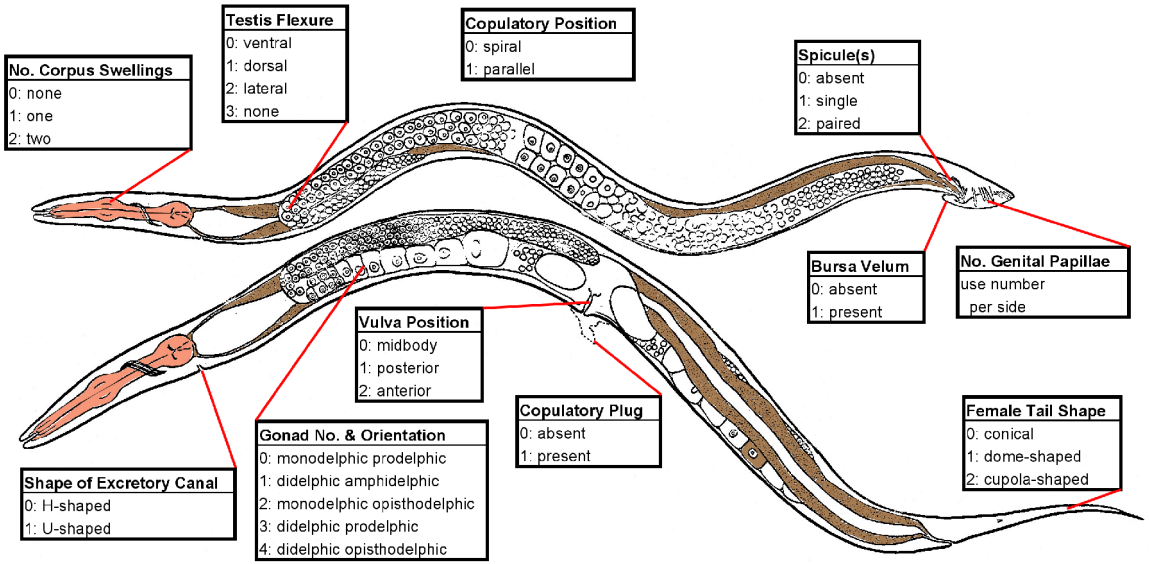
Multi-focal video images capture and communicate nematode morphology



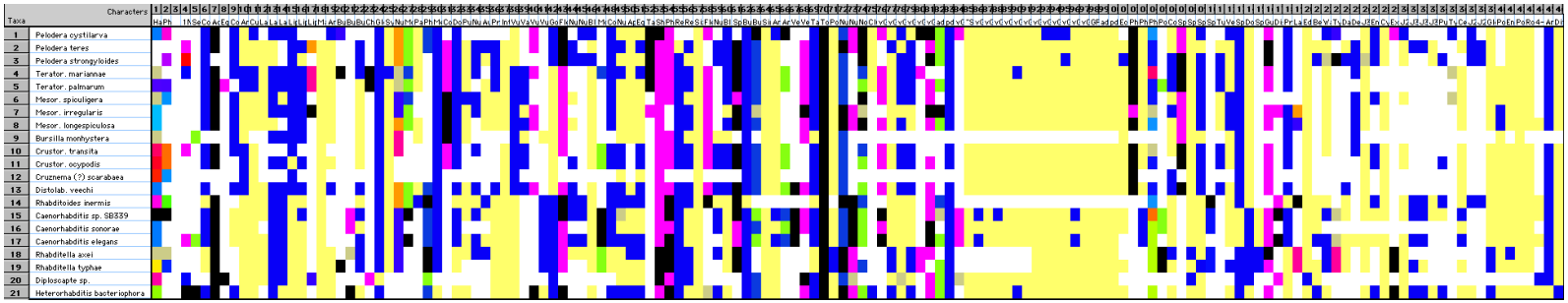
Nematodes are transparent.
Morphology is visualized at multiple focal planes.
Multi-focal video images serve as digital vouchers.

Morphological datasets

Define Characters and discrete alternative Character States



Construct Matrix

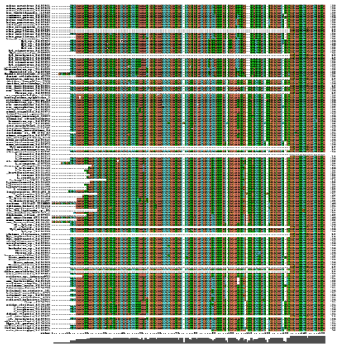


Use matrix to test compatibility with molecular data
Map character evolution onto molecular or total-evidence tree
Test for character correlations

NemAToL

nematol.unh.edu

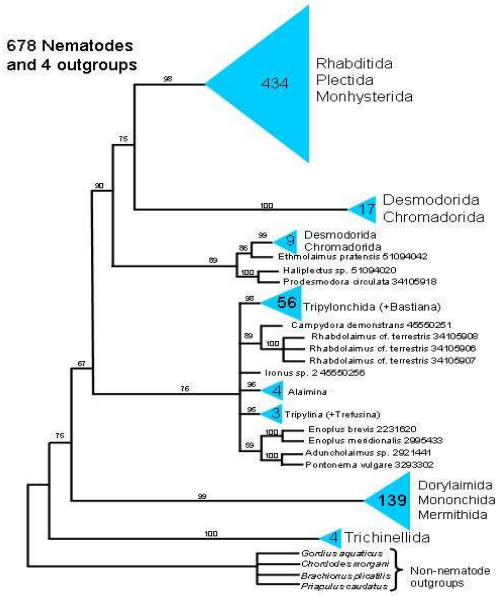
Alignments



Sequence Databases

SSU, LSU and Mitochondrial

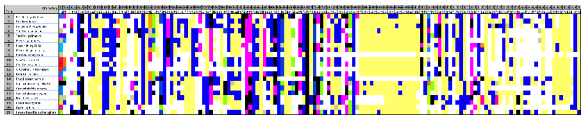
Phylogenetic Trees



NemAToL ID

Metadata

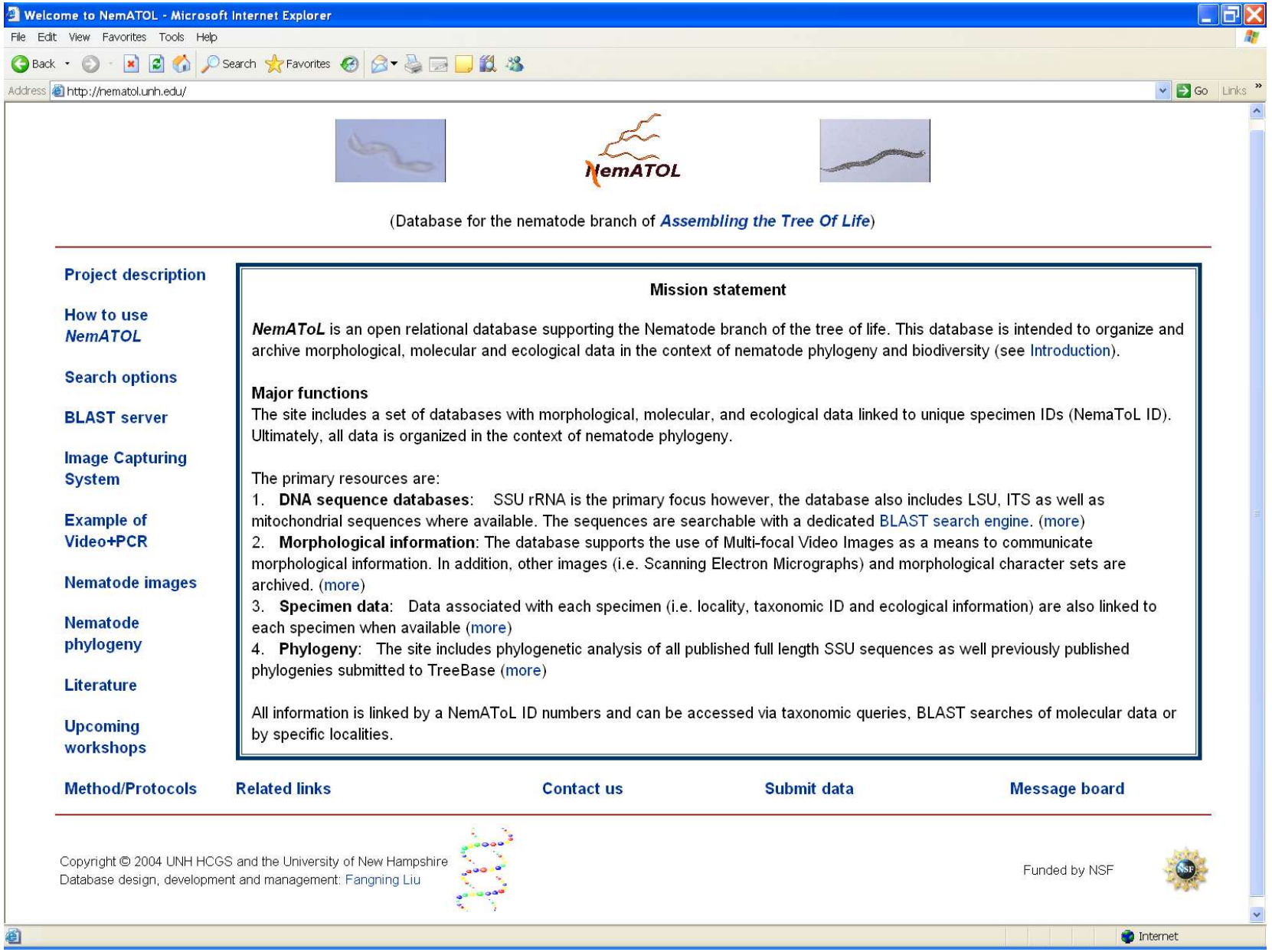
(GPS, Salinity, pH, etc.)



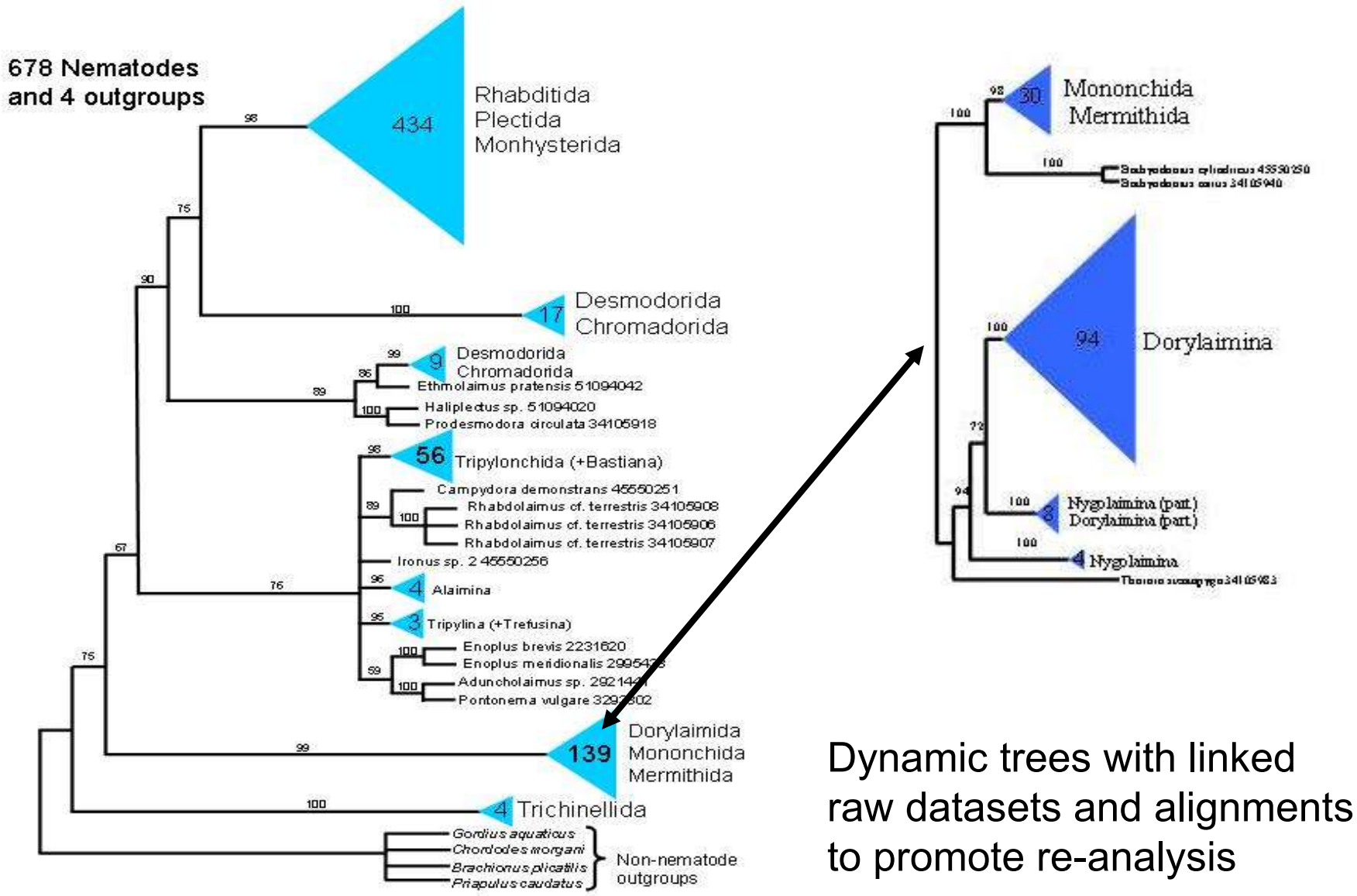
Morphology

Multi-focal Digital Vouchers

NemAToL nematol.unh.edu



Phylogenetic trees



Dynamic trees with linked raw datasets and alignments to promote re-analysis

Resources:
NYU Rhabditidae Collection of live stocks

- The collection
  - Established 1993 with 30 species
  - Doubling time = 5 years!
  - Now 131 species as 150 living strains
  - 50% maintained alive cryogenically (inexpensive maintenance)
  - Major resource for systematics, genomics, evo-devo, evolution

- Needs improvement
  - Web database
  - Cryogenic preservation
  - Supplements to AToL grants for collection improvement? (NSF LSC?)