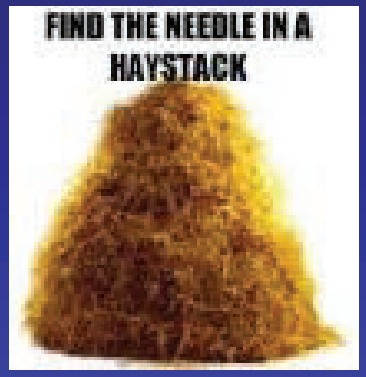
Needle in a Haystack Research Projects for Environmental Protection:

Two Down and One To Go



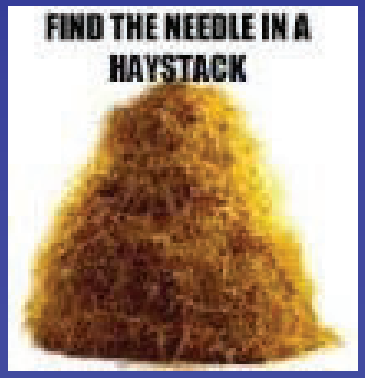
SCROLL DOWN TO SEE PRESENTATION SLIDES

Daniel P. Molloy, Ph.D.

State University of New York
Great Lakes Center at Buffalo

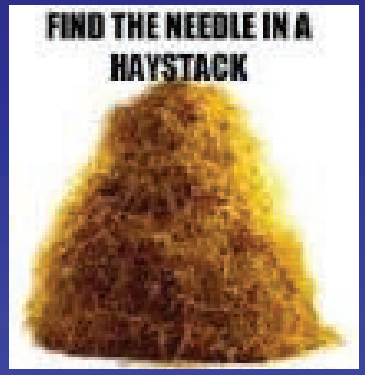
MY MINDSET AS A RESEARCHER

I'm a scientist who is attracted to looking for solutions to pest problems that have been considered by many to be intractable, unsolvable.



My Ph.D. & postdoctoral research

My first needle in a haystack project



NATIONAL INSTITUTES OF HEALTH

World Health Organization

NEEDLE IN A HAYSTACK PROJECT #1

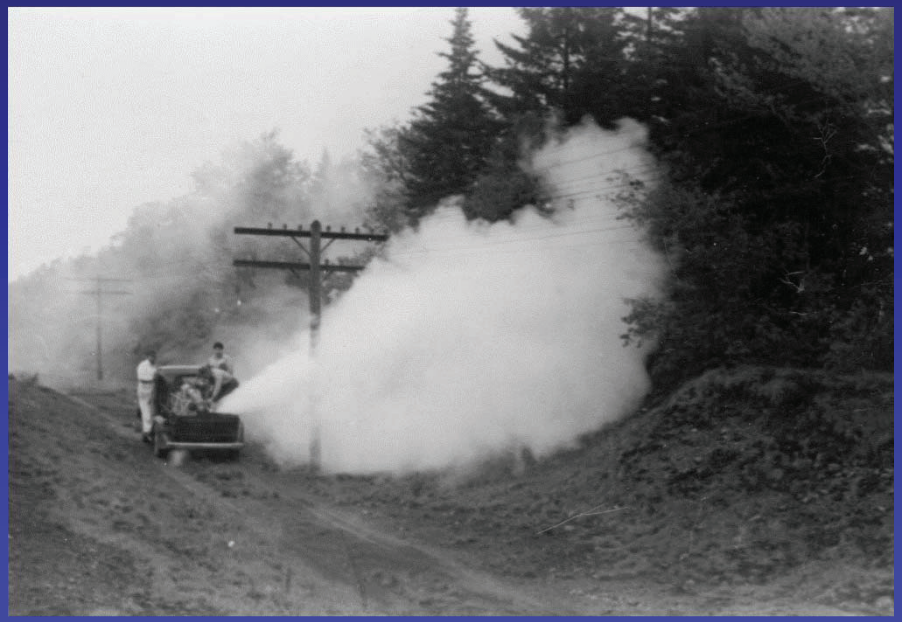
Find a biological control agent for black flies

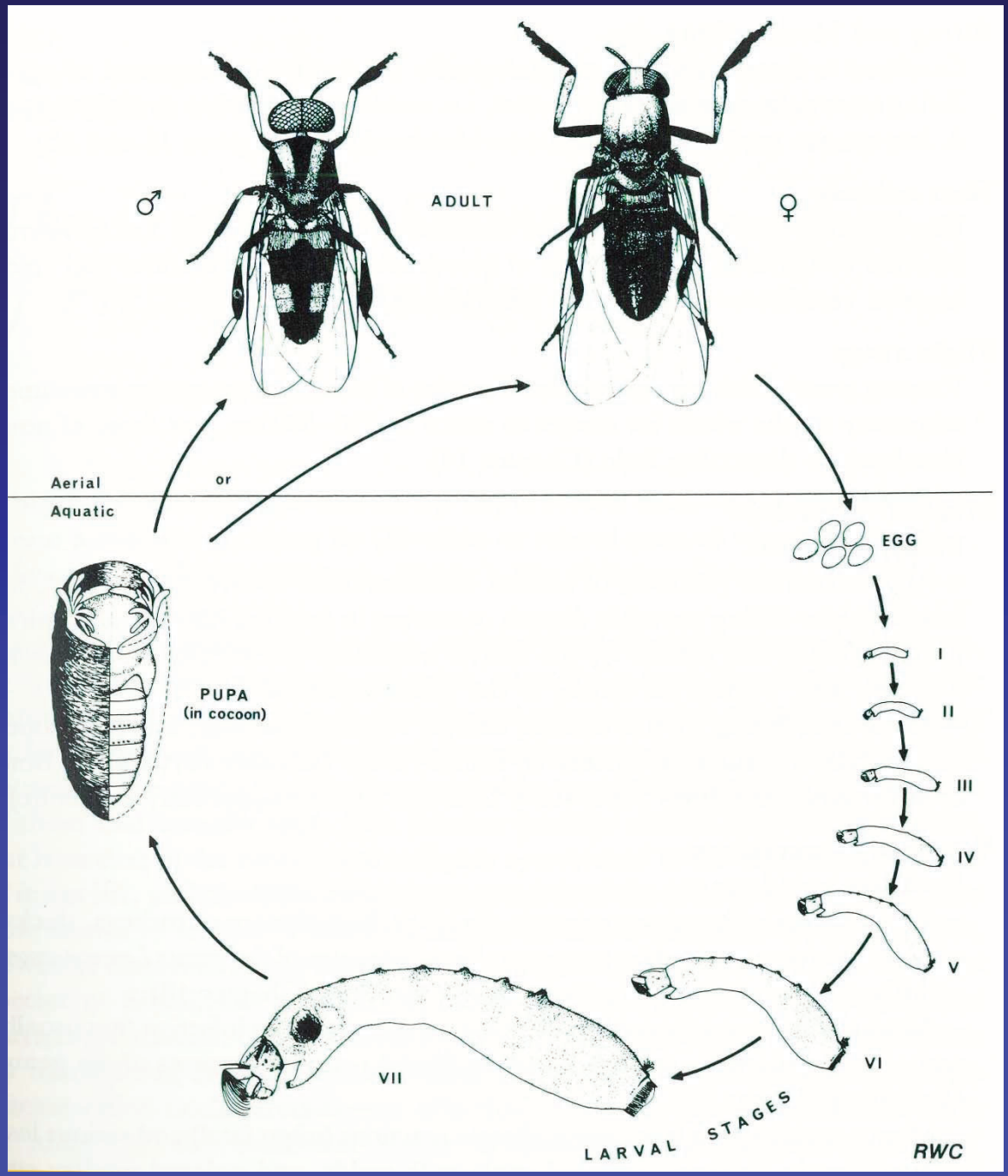
That red dot in center is a congealed pool of blood….

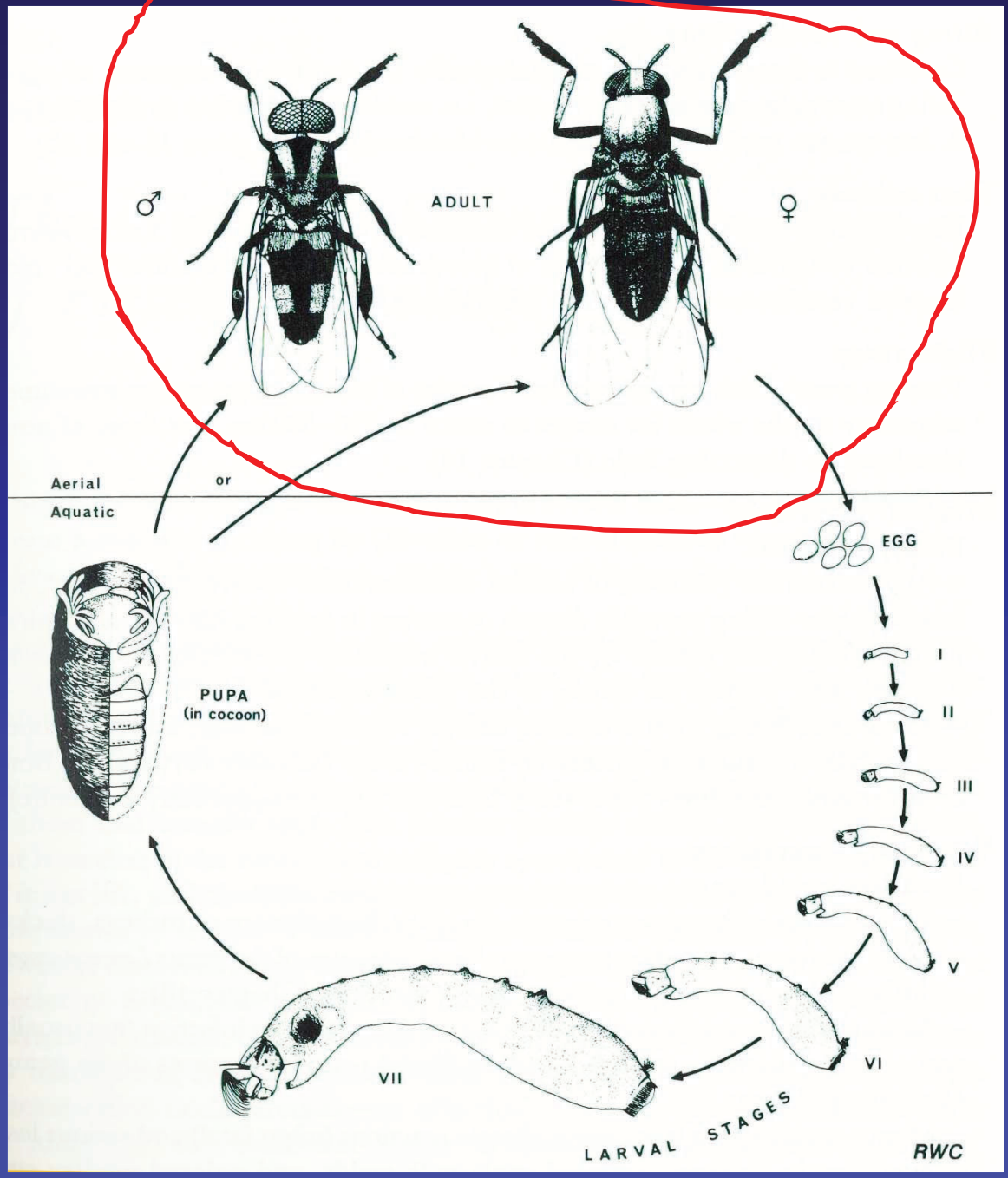
Mouth parts are short & stout

Their long stylets are armed at their tips with teeth or spines to do the cutting

Broad-spectrum chemical insecticides




♂
ADULT
♀
Aerial
or
Aquatic
EGG
I
II
III
IV
V
VI
VII
PUPA
(in cocoon)
LARVAL STAGES
RWC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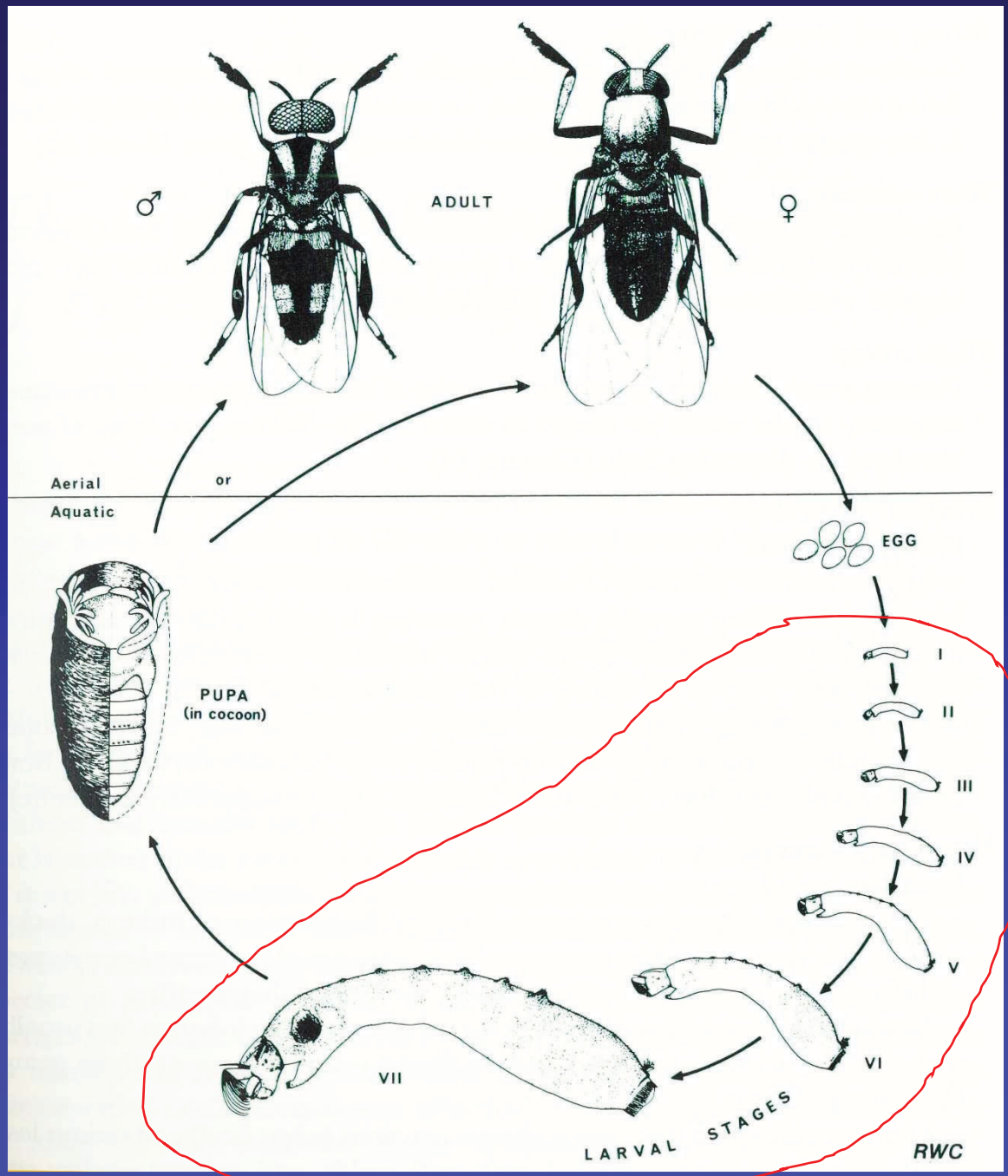
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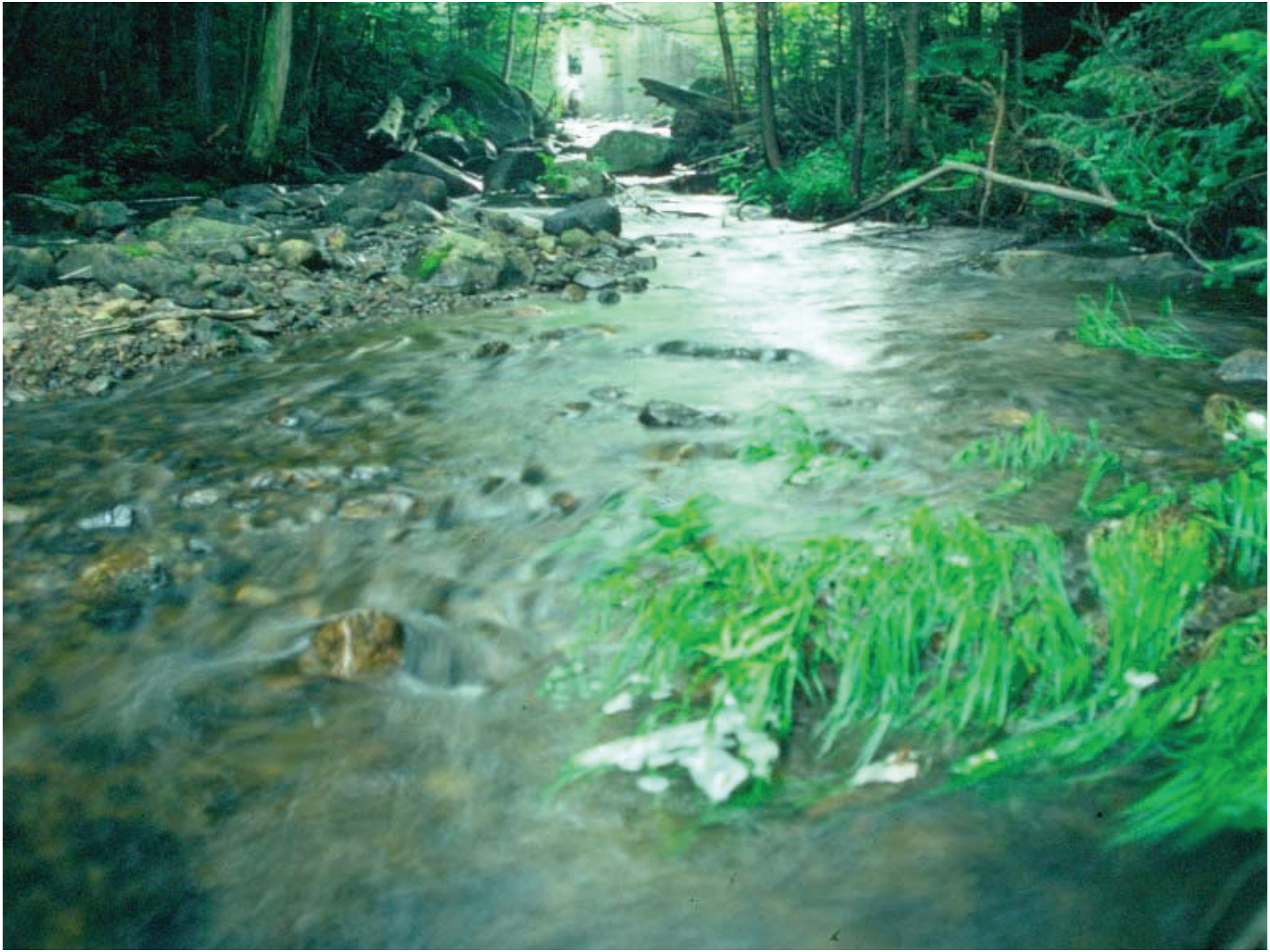
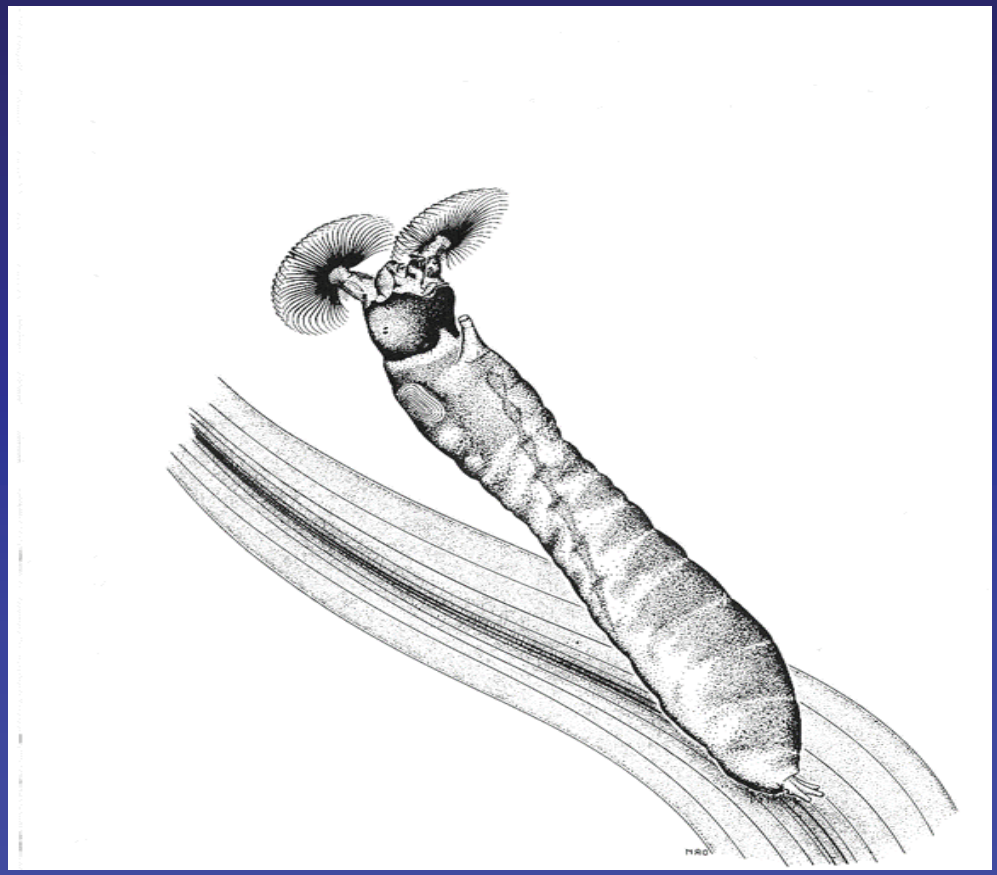
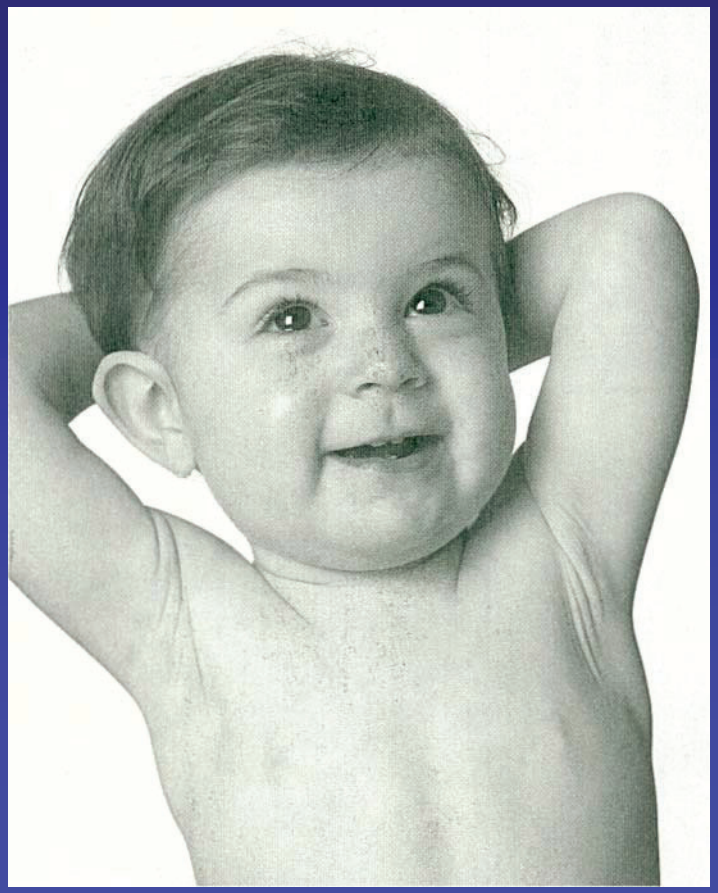


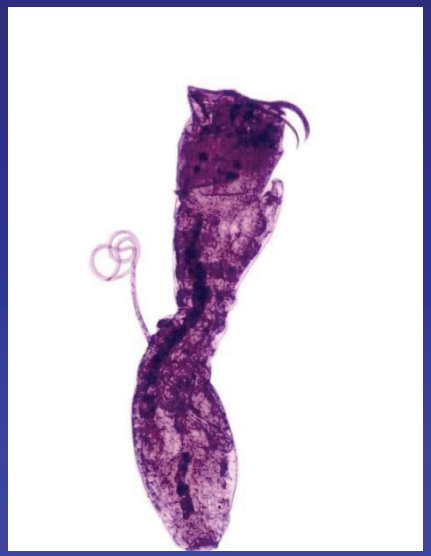


Black fly larvae die naturally from parasitic diseases

1973



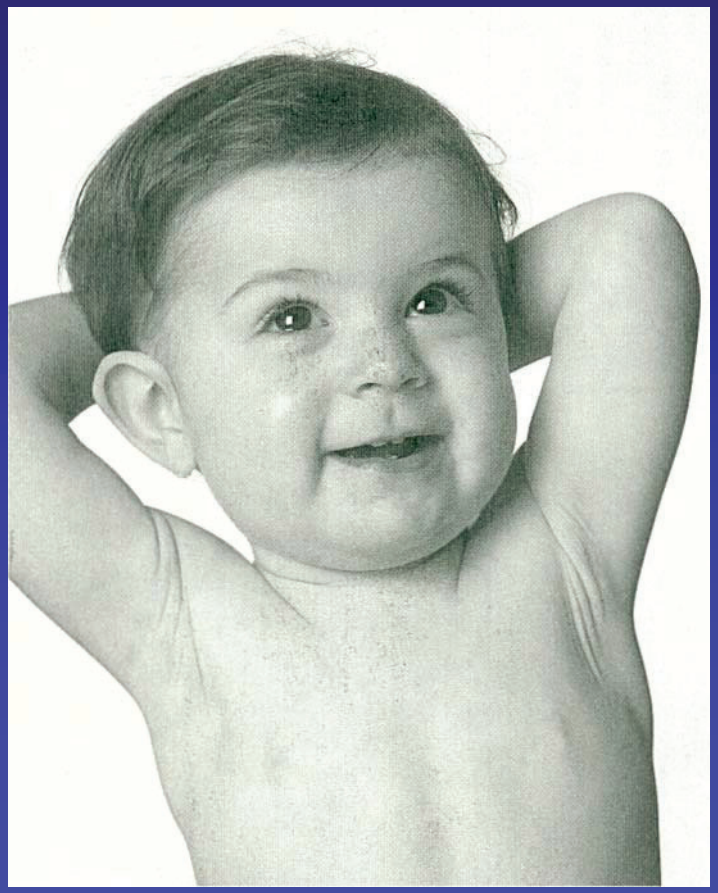
Parasitic nematodes



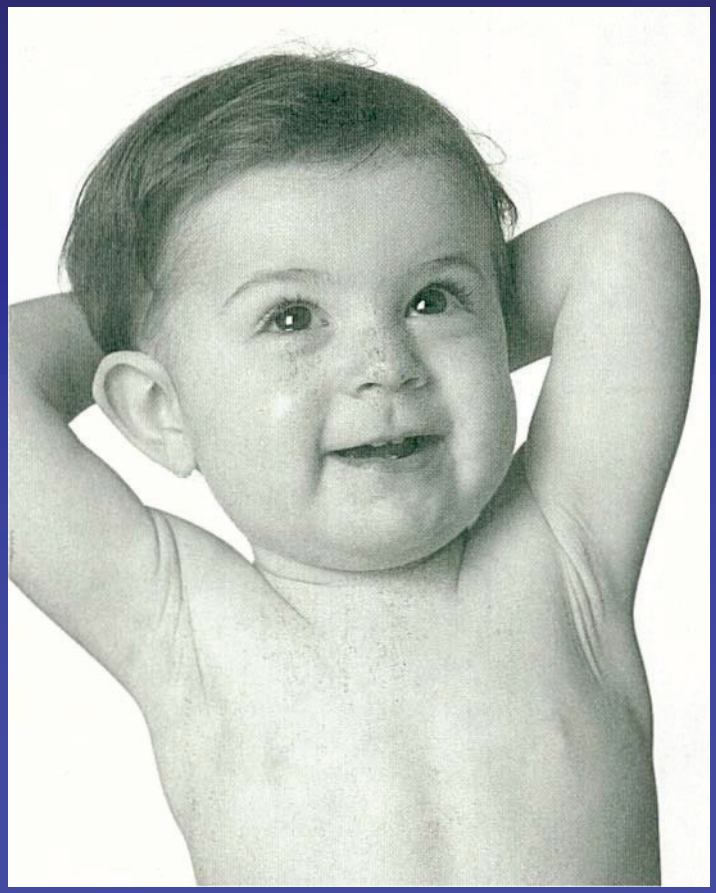
Spore-forming
microsporidians

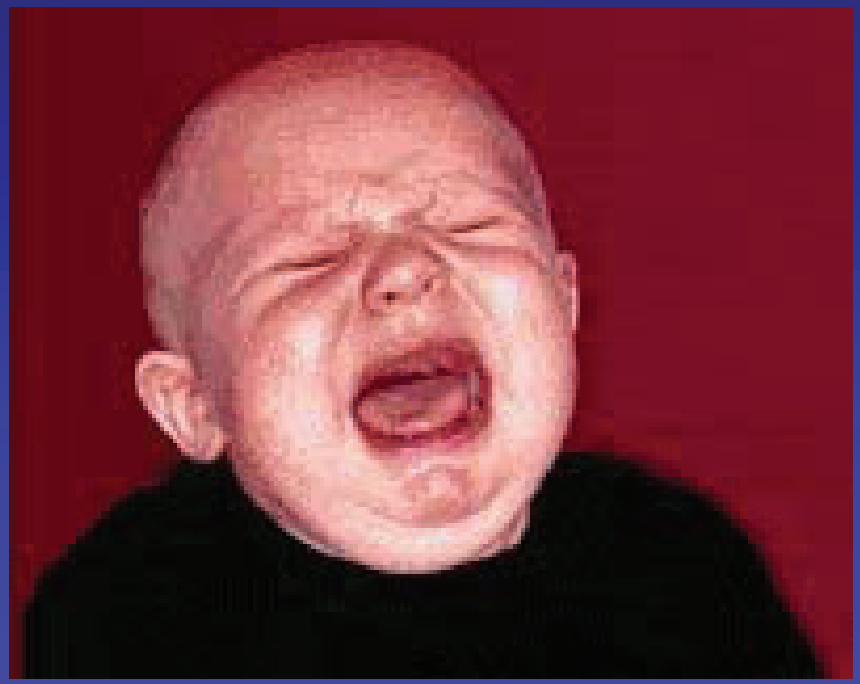
All white larvae are dying from a microsporidian infection

1973 - 1978



1973 - 1978





BLACK FLY
STOUT

GRITTY'S

BLACK FLY STOUT

Brewed & Bottled in Portland, ME By Gritty McDuff's Brewing Co. LLC

12 FLUID OZ.

7 88309 30001 3

GOVERNMENT WARNING: (1) ACCORDING TO THE SURGEON GENERAL, WOMEN SHOULD NOT DRINK ALCOHOLIC BEVERAGES DURING PREGNANCY BECAUSE OF THE RISK OF BIRTH DEFECTS. (2) CONSUMPTION OF ALCOHOLIC BEVERAGES IMPAIRS YOUR ABILITY TO DRIVE A CAR OR OPERATE MACHINERY, AND MAY CAUSE HEALTH PROBLEMS.

BEST ENJOYED BEFORE:

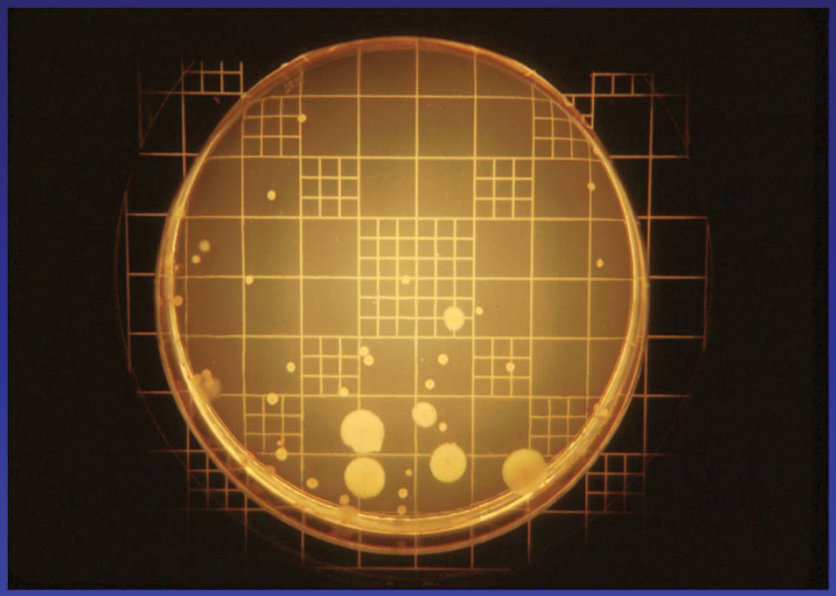
J	F	M	A	M	J	J	A	S	O	N	D	01	02	03

1979

….. but then I got a break due to a discovery by another scientist

1979

Bacterium found that killed black fly larvae!!!!

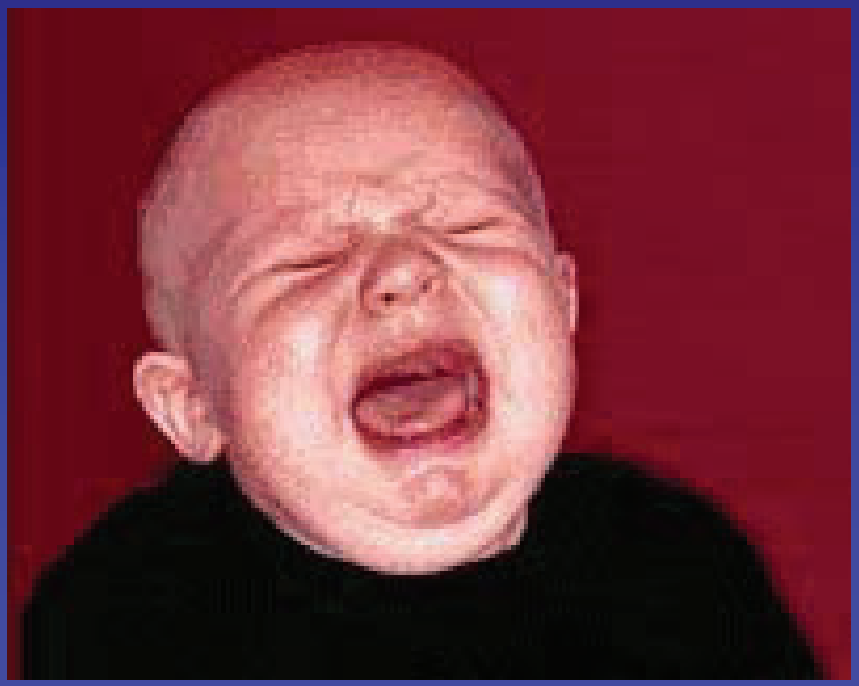


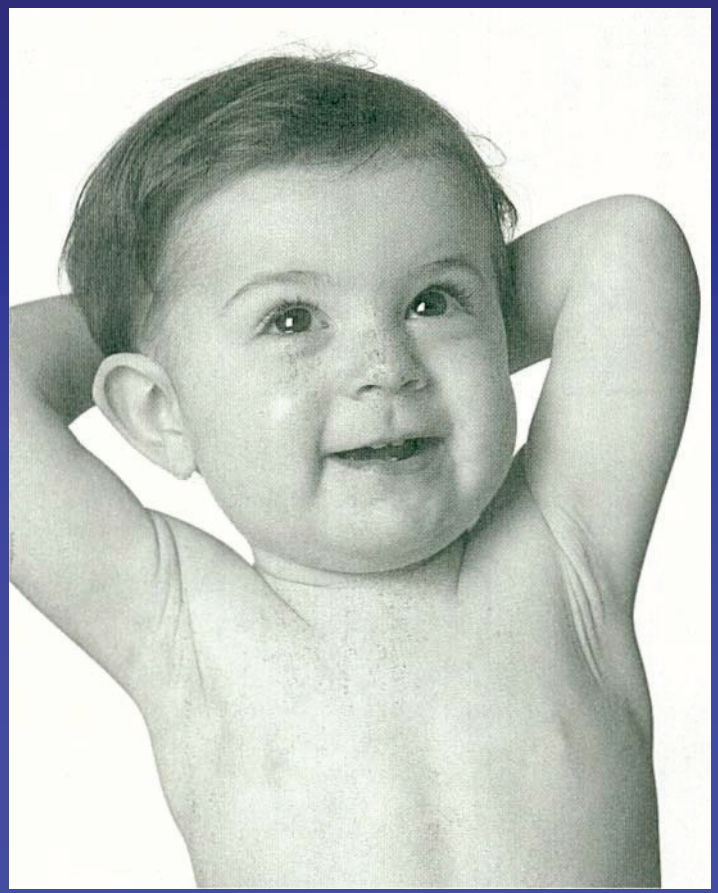
B t i

B t i

1979

(AFTER 6 YEARS OF FAILURE)





1979 – 1983

Did lab & field research

We demonstrated that *B t i* was an environmentally safe and effective biocontrol agent

Adirondack region of NY

Now 34 year history of safe and effective use

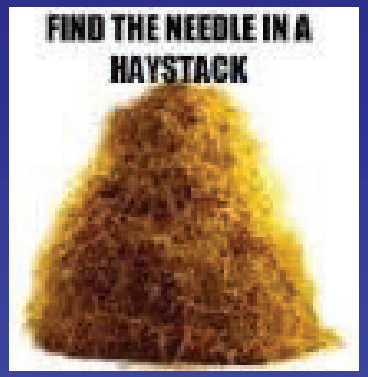
1984 – 2018

>3,400 miles of waterways

>1,400 sq. miles

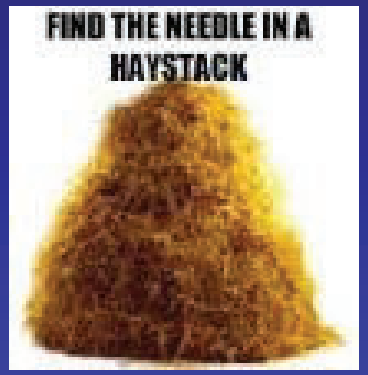
>32 towns

Needle in a haystack project #1



Success… with a little help from my friends

Needle in a haystack project #2



Control of invasive mussels from Europe

CRUISE IN 6 TO 9 PM
FRI JULY 1

S. van Mechelen

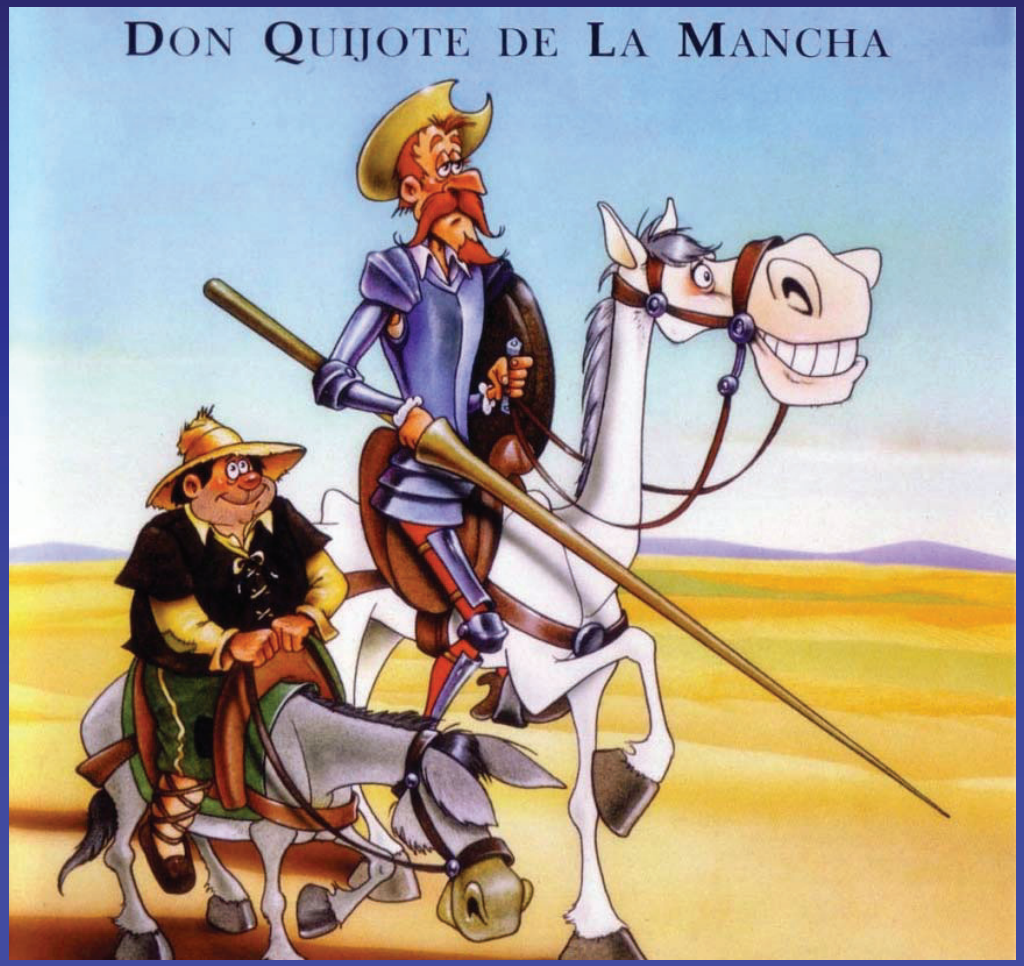
Industrial Impacts

Recreational Impacts

Cut foot Pelican Lake, MN
(Credit - Bob Gilsdorf to Fargo The Forum)

I proposed I could find another bacterium that would kill these zebra mussels!!!

…. this guy Dan Molloy is probably a biocontrol idealistic dreamer -- a scientific version of Don Quijote, Man of La Mancha….



Biocontrol Dreamer ?

But fortunately we received major funding from New York State's electric utility industry

……. to go find a environmental strain of bacterium that would selectively kill zebra mussels

1991

$ $ $

1992

$ $ $ $ $ $

1993

$ $ $ $ $ $

$ $ $

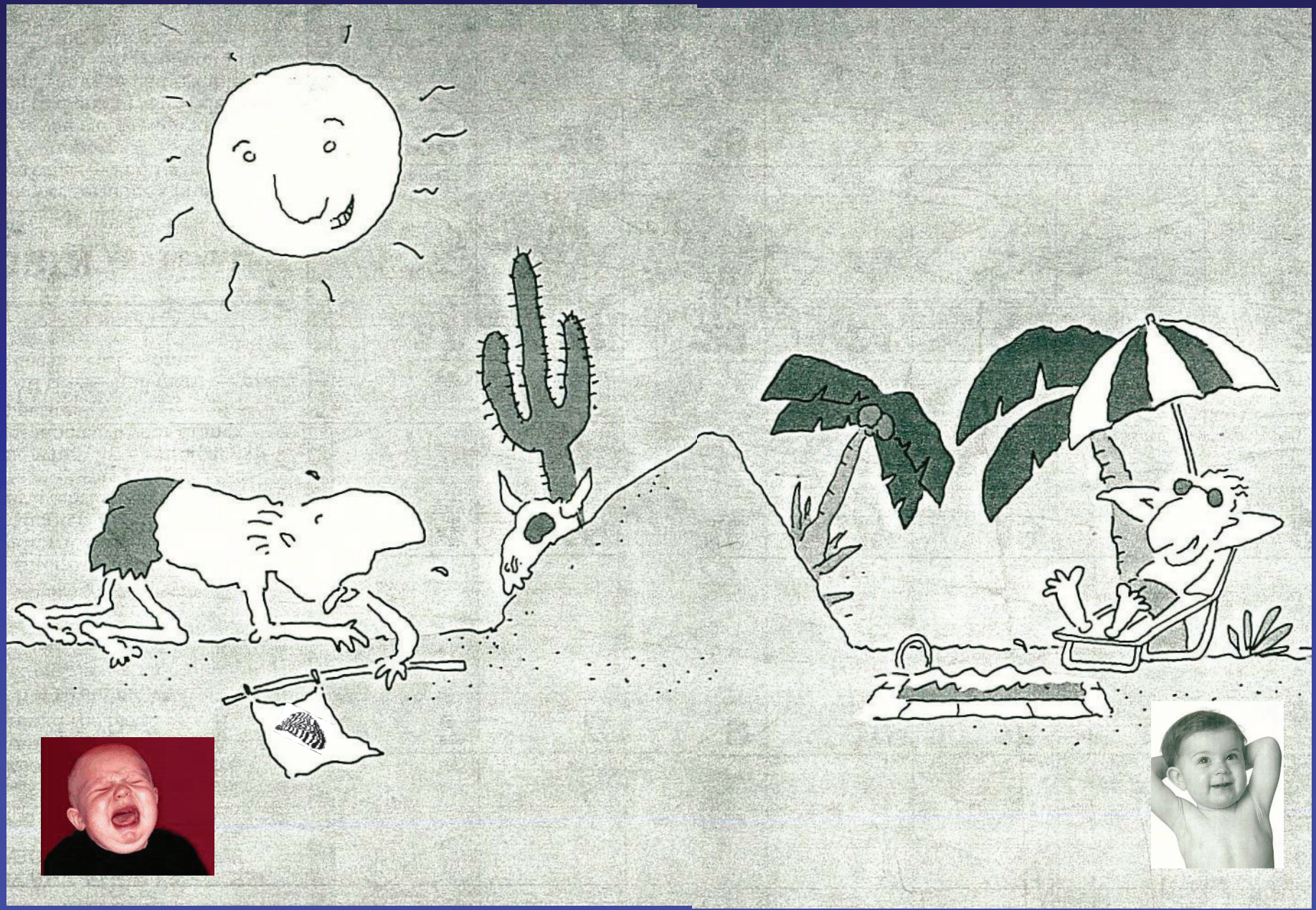
1994

>700 bacterial strains

1994

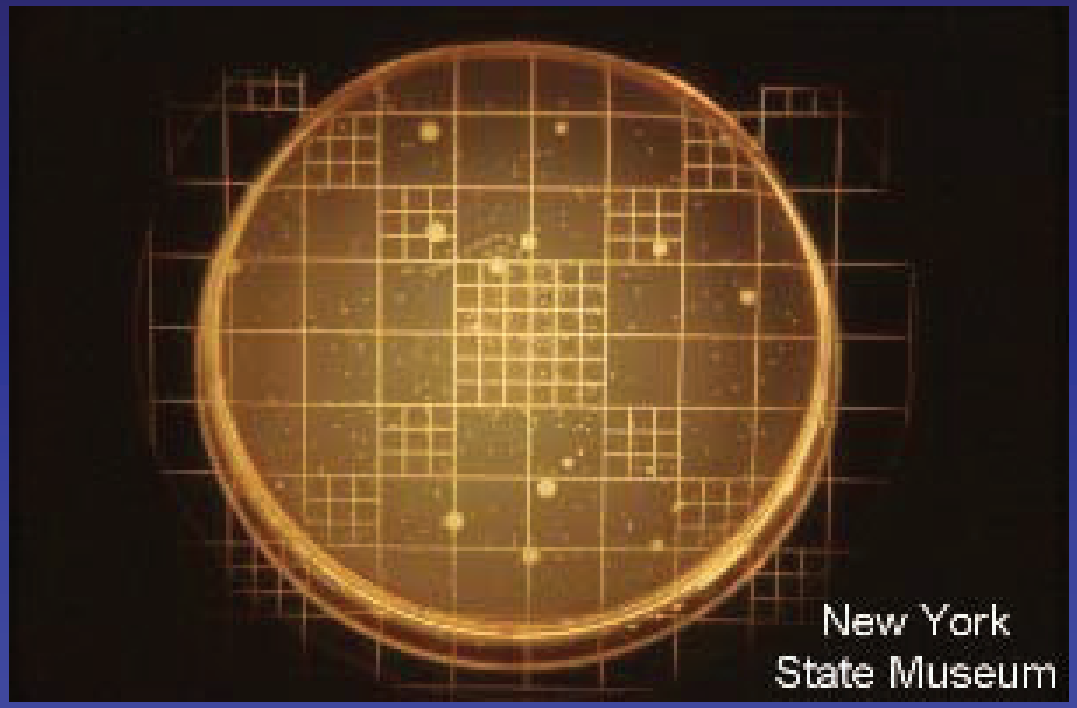
$ $ $ $ $ $

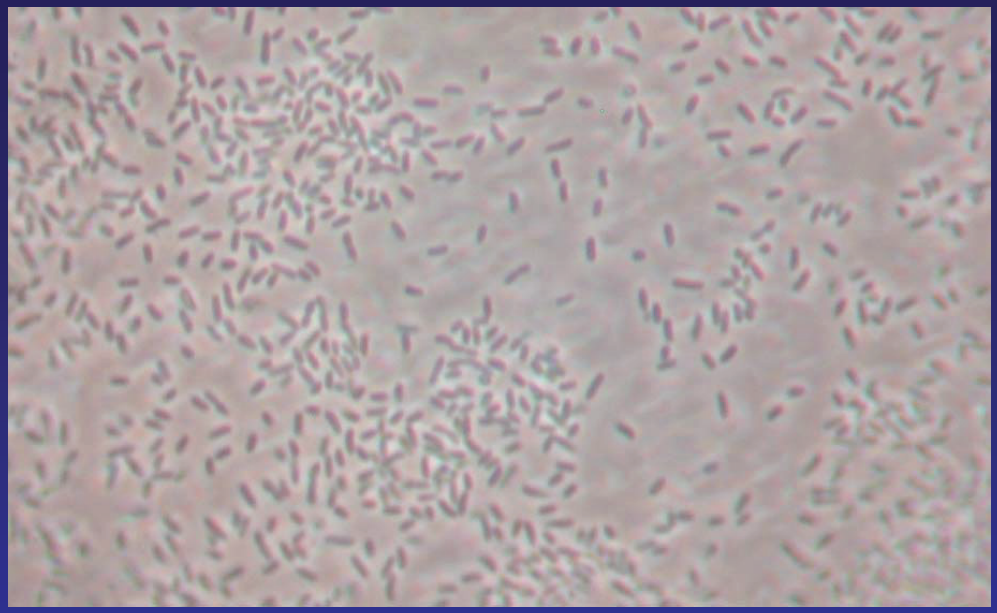
$ $ $ $ $ $

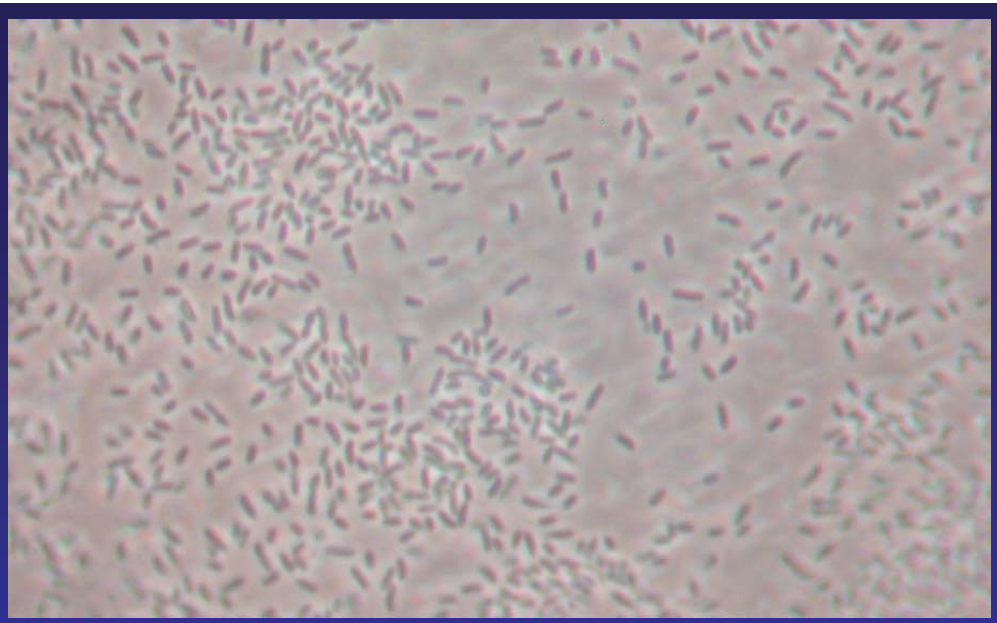


November 1994

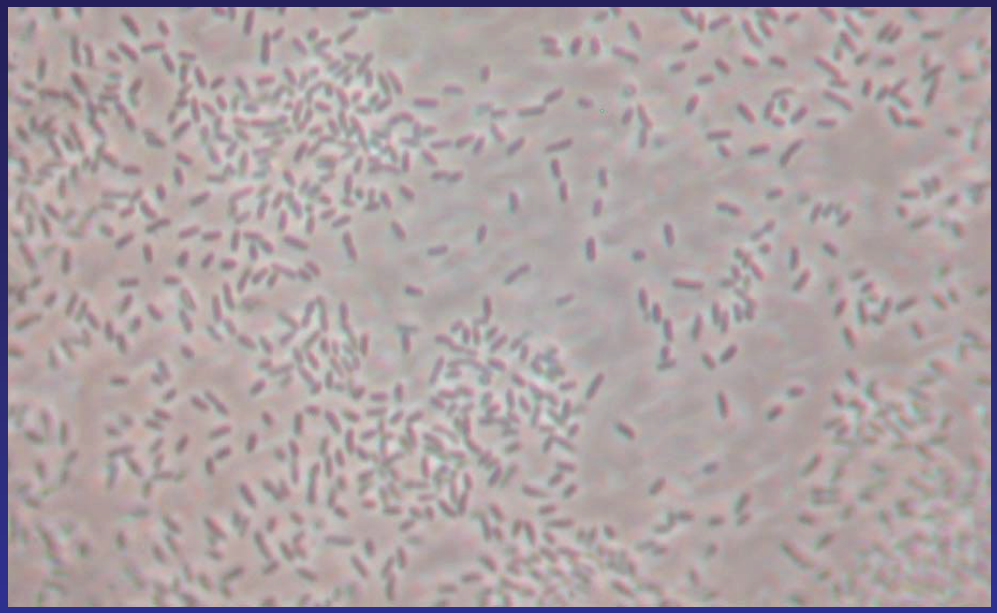
January 1995


New York
State Museum





Pseudomonas fluorescens
Strain CL145A



Pseudomonas fluorescens
Strain CL145A

Patents obtained for use of this strain for zebra mussel control

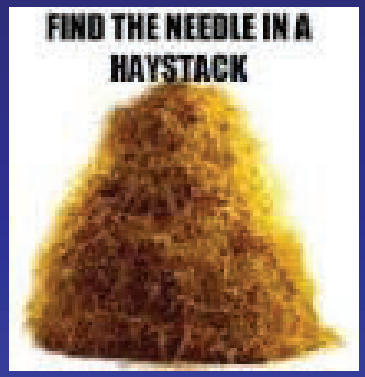
Then spent the over a decade testing the bacterium in the lab and in powerplants to confirm its effectiveness and environmental safety

2010

Use of the bacterium licensed to a California company

Biocontrol product named “Zequanox”

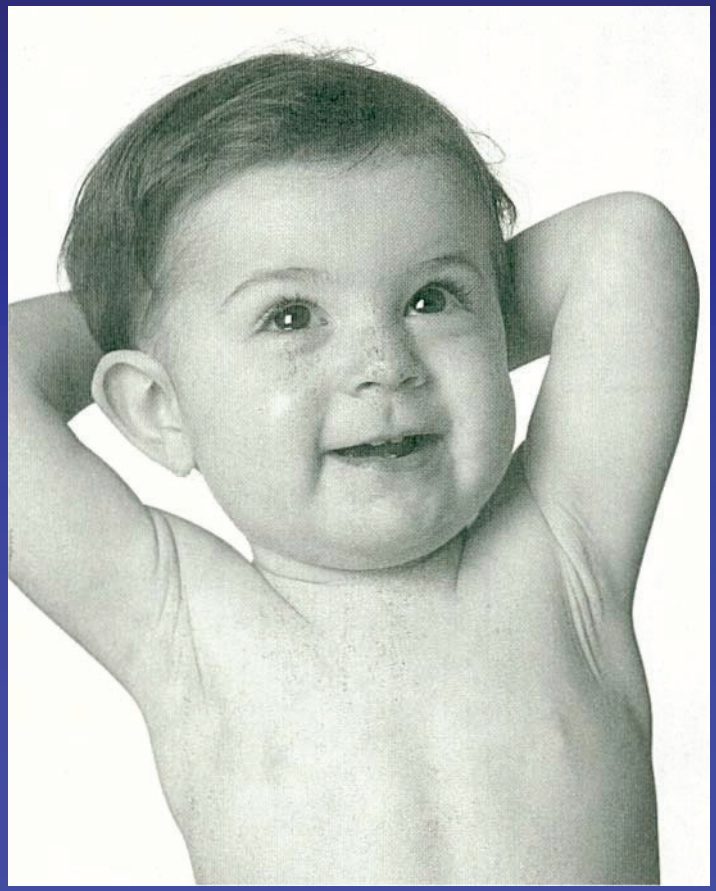
Needle in a haystack project #2



Success!

Power plants started to use this biocontrol agent to clean their pipes of zebra mussels

2010

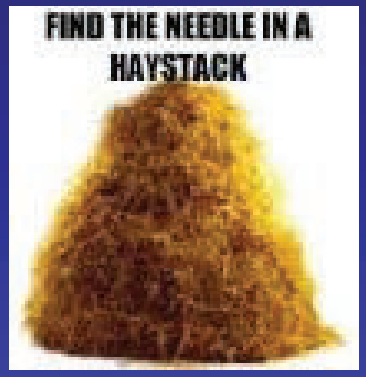


2018

Zequanox still remains the most target specific molluscicide to control these mussels in pipes

Needle in a Haystack Research Projects for Environmental Protection:

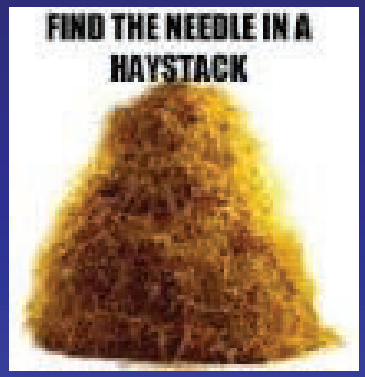
Two Down and One To Go



Daniel P. Molloy, Ph.D.

State University of New York
Great Lakes Center at Buffalo

Needle in a haystack project #3

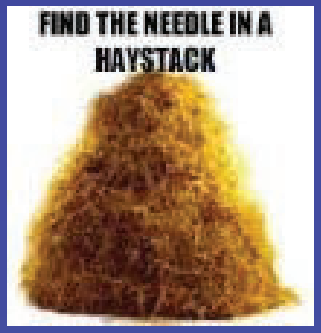


Is there a biocontrol agent that can be used to control zebra mussels in entire lakes??

Never ever in history has there been any method developed for the control of zebra mussels throughout an entire lake.

These mussels have been in Western Europe for a couple of hundred years and nobody has come up with as effective lake or river control method.

Thus, this is the most ambitious needle in a haystack project I have ever attempted.



So North America obviously has a problem with these invasive mussels….

…. and unfortunately there is currently still no control method capable of drastically reducing dreissenid populations throughout an entire water body.

Why?

….because successfully treating an entire water body is currently either:

- **Too expensive**

or

- **Too environmentally degrading**

To be ECONOMICALLY FEASIBLE controlling the mussels must be VERY INEXPENSIVE (~ one thousand fold less expensive)

To be ENVIRONMENTALLY SAFE it has to be VERY HOST SPECIFIC (the control agent should only kill dreissenid mussels)

To be economically feasible the control agent ideally must be applied only once in a small area and be:

- **SELF-PERPETUATING**
- **SELF-SPREADING**

Thus, this control agent must be LIVE

It must be a BIOCONTROL agent…
……but what kind of biocontrol agent…???

Reviews in Fisheries Science, 5(1): 27-97 (1997)

Natural Enemies of Zebra Mussels: Predators, Parasites, and Ecological Competitors

Daniel P. Molloy,[1] Alexander Y. Karatayev,[2] Lyubov E. Burlakova,[2] Dina P. Kurandina,[3] and Franck Laruelle[1]

[1]Biological Survey, New York State Museum, The State Education Department, Cultural Education Center, Albany, NY 12230, [2]Lakes Research Laboratory, Belarusian State University, F. Skoryna Ave. 4, Minsk, 220050 Belarus; [3]Institute of Hydrobiology, Ukrainian Academy of Sciences, 12 Prospect Geroyev Stalingrada, Kiev-210 254655 Ukraine

ABSTRACT: This paper reviews the international literature on the natural enemies of *Dreissena* spp. and discusses the biology and ecology of organisms known to be involved in their predation (176 species), parasitism (34 species), and competitive exclusion (10 species). Research on natural enemies, both in Europe and North America, has focused on predators, particularly birds (36 species) and fish (15 and 38 species eating veligers and

The control agent must be a PARASITE

…. because among all types of natural enemies, parasites are the most host-specific killing agents

…. And not any host-specific parasite will do…

…. It's got to be a HYPERVIRULENT PARASITE

This project is an extremely ambitious one

This project is an extremely challenging one

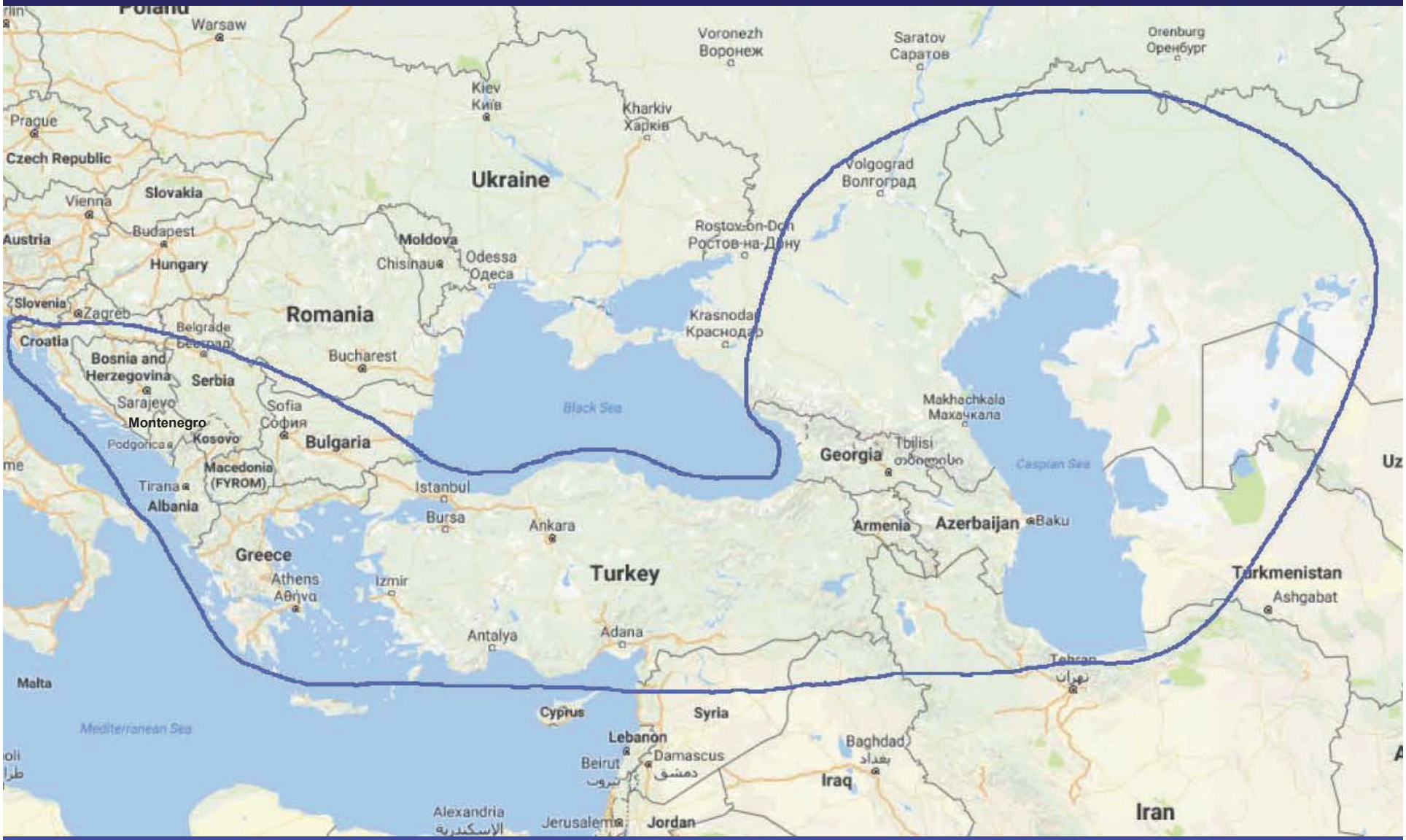
But I am confident there is a parasite already existing in nature that could be this future biocontrol agent

But I and my international team just have to find it

It's out there

Area in past that we have focused on looking for parasites in the same two *Dreissena* spp. as we have in North America:
- *D. polymorpha* (zebra)
- *D. rostriformis* (quagga)
United Kingdom
Ireland
France
Germany
Poland
Belarus
Ukraine
Romania
Bulgaria
Italy
Spain
Portugal
Turkey
Greece
Estonia
Latvia
Lithuania
Denmark
Netherlands
Belgium
Switzerland
Austria
Hungary
Slovakia
Czech Republic
Moldova
Serbia
Albania
Georgia
Armenia
Azerbaijan
Uzbekistan
Turkmenistan
Afghanistan
Iran
Iraq
Syria
Lebanon
Tunisia
Morocco
Malta
Cyprus

Area we have switched to… focusing on possible “novel” parasites from other dreissenid species


Poland
Warsaw
Voronezh
Воронеж
Saratov
Саратов
Orenburg
Оренбург
Kiev
Київ
Kharkiv
Харків
Prague
Czech Republic
Ukraine
Volgograd
Волгоград
Slovakia
Vienna
Austria
Budapest
Hungary
Moldova
Chisinau
Odessa
Одеса
Rostov-on-Don
Ростов-на-Дону
Slovenia
Zagreb
Romania
Krasnodar
Краснодар
Croatia
Belgrade
Bucharest
Bosnia and
Herzegovina
Serbia
Sarajevo
Black Sea
Makhachkala
Махачкала
Montenegro
Sofia
София
Podgorica
Kosovo
Bulgaria
Georgia
Tbilisi
Caspian Sea
Macedonia
(FYROM)
Tirana
Albania
Istanbul
Bursa
Ankara
Armenia
Azerbaijan
Baku
Greece
Athens
Αθήνα
Izmir
Turkey
Turkmenistan
Ashgabat
Antalya
Adana
Malta
Cyprus
Syria
Mediterranean Sea
Lebanon
Beirut
بيروت
Damascus
دمشق
Baghdad
بغداد
Iraq
Alexandria
الإسكندرية
Jerusalem
Jordan
Iran

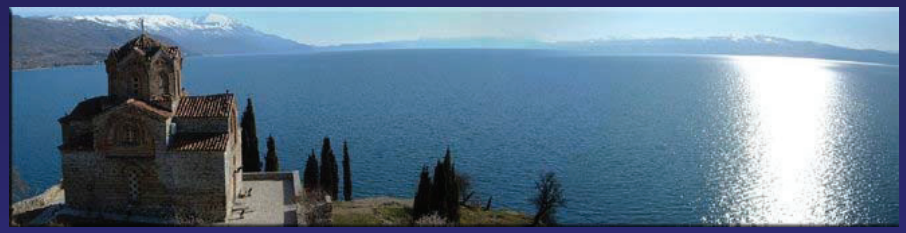
A very high priority of this project is to sample the parasites from *Dreissena* spp. endemic to:

-- the Balkans (e.g., *D. blanci*, *D. carinata*)

-- Turkey (e.g., *D. caputlacus*, *D. anatolica)*

These latter samples will be particularly valuable because North American dreissenid populations have not likely encountered the parasites from these latter four *Dreissena* spp.

Thus infection may prove highly virulent to them.



Lake Ohrid

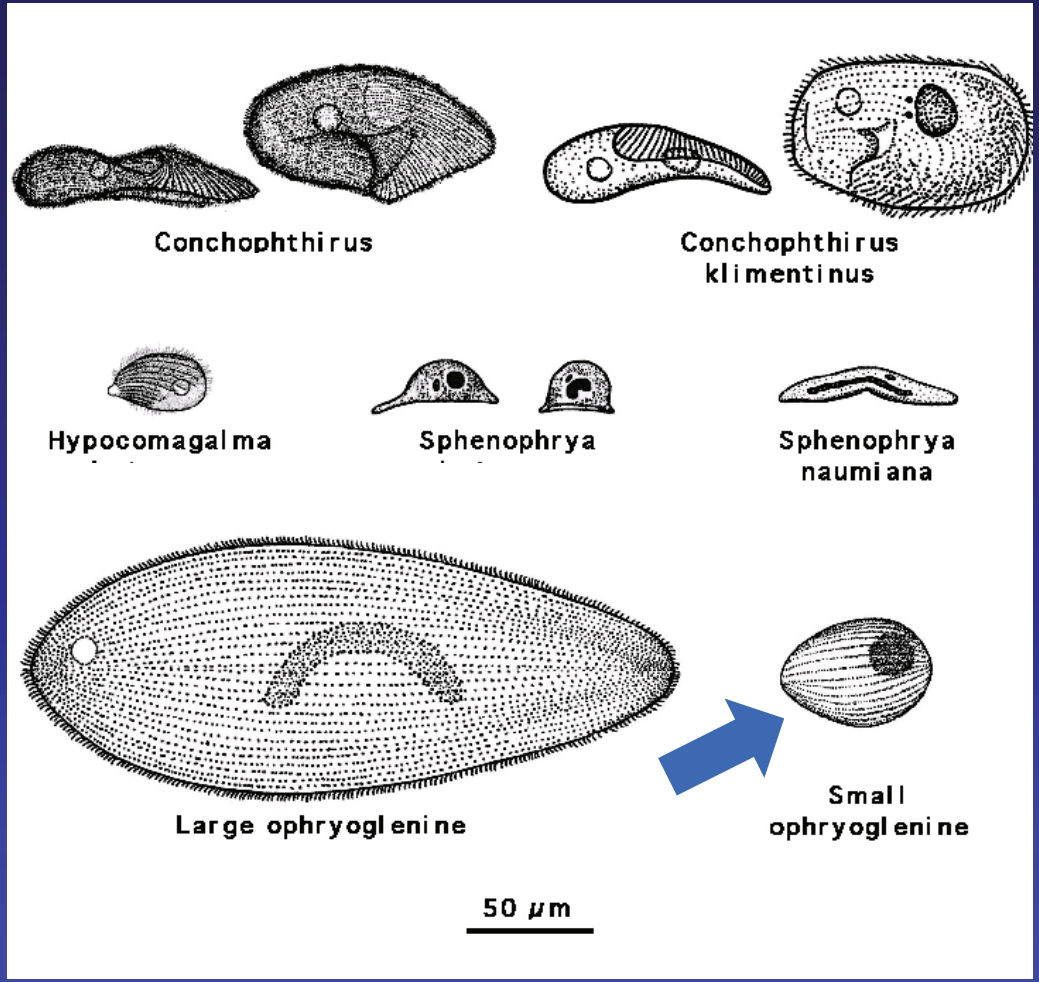
Skadar Lake

There's only one dreissenid species in these lakes: *D. carinata*

…and we have already found parasites in this dreissenid

…. and in in *D. carinata* we are finding morphologically similar parasites …… that sequencing indicates are NOT the same species as in zebra and quagga mussels

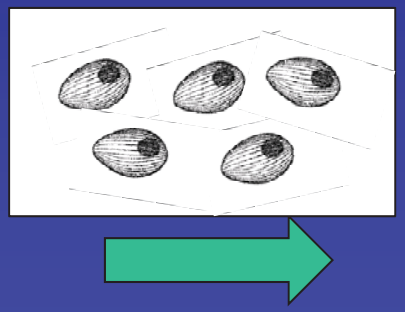
These are examples of potentially "novel" parasites that need to be screened for possible "hypervirulence" to zebra and quagga mussels



Next logical research step is to try to infect zebra and quagga mussels with parasites that have co-evolved with *D. carinata*

Could some relatively harmless parasite from *D. carinata* be hypervirulent to "naïve" zebra/quagga mussels and kill them?

D. carinata



TAKE HOME MESSAGE

Will there ever be lake-wide biocontrol of dreissenids in North American waterbodies?

Don’t give up on the use of parasites for that purpose

Hey, it’s just another needle in a haystack project that needs to be solved!

Thanks for your attention !