

# Outdoor Empire

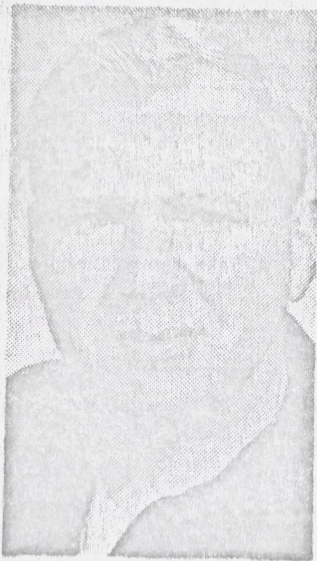


## Ancient Trout Species Found

By Bob Saile

HUNDREDS OF centuries before the white man ever set foot in the territory that is now Colorado, a beautiful fish with a dark-spotted, greenish-golden body and red slash marks under its jaw was the only trout that swam in the pure waters of the region. Later, man was to give him three commonly used names: Greenback trout, cutthroat trout and, technically, *Salmo clarki stomias*.

This once ubiquitous trout was found throughout three major river drainages in Colorado—the Colorado, the Arkansas and the Rio Grande. Today, modern versions of the



ROBERT BEHNKE

cutthroat are found in a relatively few redoubts in the high country, his range usurped by the coming of people and his trout cousins. The rainbow trout was brought here from the Pacific Coast about 1880, the eastern brook trout from the East Coast about the same time, and the brown trout from Europe in about 1890.

*Salmo clarki stomias* didn't compete well with humans and other trout. The cutthroats that Colorado has in 1970 are mostly imported versions—beautiful fish, but not the original greenback.

It is, therefore, a minor miracle of nature that a population of apparently pure greenbacks has been discovered in a tiny mountain stream no more than 40 miles from the smog-shrouded spires of downtown Denver. Robert J. Behnke, an assistant professor of fishery biology at Colorado State University, has scientifically identified the fragile inhabitants of this stream as original cutthroats. The stream, which has no name, is near Nederland, Colo., not far from a highway. It's a tributary of North Boulder Creek and lies in Roosevelt National Forest.

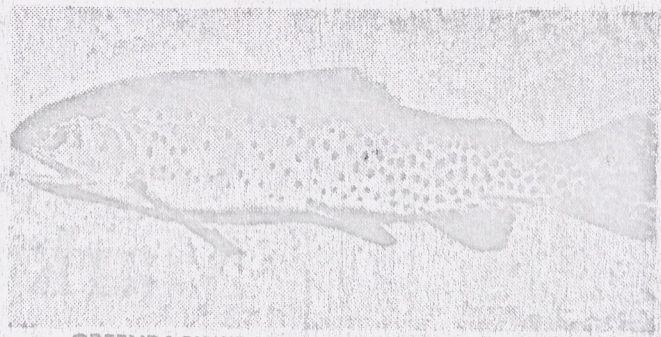
### Trout Examined at CSU

Acting on a tip, Behnke and an assistant, Gary Wernsman, went to the stream in September of last year and collected several trout by electro-fishing.

Back at Fort Collins, Behnke, assistant unit leader of the Colorado Cooperative Fishery Unit at CSU, painstakingly examined the trout. It's impossible to identify accurately a trout as a native greenback by simply looking at it. One of the keys to identification is the number of vertebral segments in the fish's bone structure.

The counts from the specimens ranged from 59 to 61 segments. This is a characteristic of a greenback—counts on subspecies of cutthroats are typically 61 to 62; counts on rainbow trout are typically 63 to 64.

"This creek is so small you'd hardly notice it," Behnke said. "The stream runs right through a culvert beside a



### GREENBACK TROUT—A COLORADO NATIVE

Forest Service road, and I guess it's so small nobody bothers to fish it."

How does he account for the existence of these lonely throwbacks to history?

"Well, there are no lakes or ponds at the head of this stream, and that's probably the reason it has never been stocked with other trout," said Behnke. "Another reason there are no other kinds of trout in it is the fact that the stream drops 500 feet in a distance of a half-mile before joining North Boulder Creek. No other fish can get upstream."

### Some Greenbacks Transplanted

A few days ago, Behnke cooperated with biologists of the National Park Service in an effort to transplant some of the stream's greenbacks to a small stream in Rocky Mountain National Park.

About 50 of the cutthroats were placed in a tank and driven to the Stanley Hotel at Estes Park, where a helicopter hired by the Park Service picked them up and ferried them to a small tributary in the Big Thompson River drainage, in the northwestern section of the park. There were no other trout in this unnamed stream, which can be reached overland only by several miles of trail.

The helicopter landed and the trout were planted by hand.

The cutthroat project, Behnke said, is part of the Park Service's commitment to perpetuating and re-establishing indigenous species of plants and animals in the country's national parks.

Previous efforts have been made to re-establish greenbacks in Black Hollow Creek, a tributary of the Poudre River in Larimer County. The first try, in a cooperative effort with the Forest Service and other agencies, was in 1968, when 10 greenbacks from Albion Creek (another North Boulder Creek tributary) were transplanted to Black Hollow Creek. (Behnke believes the Albion Creek greenbacks by now are extinct.)

Two surveys of Black Hollow Creek in 1969 failed to turn up any sign of the transplants or evidence of reproduction. Last April, 52 greenbacks were taken from the small stream near Nederland to be stocked in Black Hollow, but they died from a fungi disease before they could be transplanted.

In June, 42 more greenbacks from the Nederland area stream were transplanted to Black Hollow Creek. The results of that transplant aren't known yet.

Behnke knows of two other spots on the Eastern Slope where almost pure greenbacks exist. One is in Rocky Mountain National Park and the other is on the North Boulder Creek drainage.

He says the greenback is his "sentimental favorite" of all fish. "It's a beautiful fish," he said, "and I guess I have a sympathy for the underdog."

Dr. Behrke  
Coop units

Notice to Reviewers:

Recently, two significant facts became known which concern relationships in the trouts under discussion.

Dr. R. R. Miller found a single basibranchial tooth in a specimen of Arizona "golden" trout which he is in the process of describing. This is more definite evidence on a cutthroat influence in their phylogeny.

Ray Simons at the University of Washington has examined the chromosomes of the California golden trout, S. aguabonita and found the diploid number to be 58, thus differing from both the rainbow and cutthroat species.

Mr. Dale V. Lockard

-2-

June 2, 1967

if you could get hold of a copy of this paper I think you would find much of interest in it.

I am greatly interested in the perpetuation of the Nevada population and appreciate your keeping me informed on what you are doing with it.

Sincerely,

Robert R. Miller  
Curator of Fishes

RRM:mw

cc: Robert J. Behnke

UNIVERSITY MUSEUMS  
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ANN ARBOR, MICHIGAN, U. S. A.  
48104

MUSEUM OF ZOOLOGY

May 26, 1967

Dr. Robert J. Behnke  
Colorado Cooperative Fishery Unit  
Colorado State University  
Fort Collins, Colorado 80521

Dear Bob:

Thank you for your letter of May 18 and the annotated list of native fishes of the Colorado River basin.

I note that you have omitted from that list the genera Elops, Mugil, and Eleotris, all of which penetrate well into fresh water of the lower segment of the Colorado River in Arizona and California.

I agree with you that native cutthroat trout probably did not occur downstream below the San Juan River basin on the east or the Dirty Devil River on the west.

I certainly think there is room for considering that the bonytail may well be a species separate from Gila robusta. I have been leaning more toward this view myself during the past year and I am quite sure that Minckley feels that it should be so treated.

During the several visits to Dinosaur National Monument that I made after the poisoning of the Green River I found the Colorado squawfish to be fairly common and I am wondering whether this species should be labeled "rare". There is, of course, no question that its range has contracted greatly, especially in the lower Colorado system, but I question whether it is rare in the same sense that Gila cypha seems to be rare.

Miller and Hubbs recognize only two subspecies of Lepidomeda mollispinis; we regard L. albivallis as a separate species.

According to the latest information I have from Minckley I don't believe we can currently classify Lepidomeda vittata as a rare species. I do not know what the basis is for your statement, "It was once believed extinct..."; this is news to me.

Poeciliopsis occidentalis is one of the rarest fishes in the Colorado River system as I believe it is now confined to only two springs, closely associated, at one of which there is a very sparse population.

You have probably already noted that "L." should be deleted after Cottus bairdi. At least I know of no records of this sculpin from other than the region above Grand Canyon.

Dr. Robert J. Behnke

-2-

May 26, 1967

I hope we can find some time around the meetings to sit down and look at your data on Gila. I remember making a note about Gila gibbosa having priority over Tigoma intermedia and I will recheck this before seeing you.

As I assume you have noted, there will be an evening Endangered Species Session on June 20 and you will no doubt wish to enter into the informal discussion that is planned.

Sincerely,



Robert R. Miller  
Curator of Fishes

RRM:mw

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JUN 5 1967

F I A S  
 COLORADO COOP.

MUSEUM OF ZOOLOGY

June 2, 1967

Dr. Robert J. Behnke  
 Colorado Cooperative Fishery Unit  
 Colorado State University  
 Fort Collins, Colorado 80521

Dear Bob:

Enclosed is a more or less self-explanatory letter from Nevada fisheries biologist Dale Lockard regarding what I judge to be a pure strain of cutthroat trout. These occur in Pine Creek, Spring Valley, on the west slope of the Snake range west of Baker.

I first saw preserved material from this locality in 1953. One of the distinctive features of the stock is the strong and numerous basibranchial teeth which number about 23 to 34.

Apparently the original stock was brought into Spring Valley before 1881, presumably from Trout Creek, Utah. This introduction is documented in the paper that I wrote with Ray Alcorn on the introduced fishes of Nevada, a reprint of which is being sent under separate cover. Presumably the trout from Trout Creek, Utah, represented the native stock, Salmo clarki utah. - this is not similar to "utah"

Possibly you have already seen specimens from Spring Valley but, if not, you should certainly examine some. Mr. Lockard is most cooperative and is endeavoring to perpetuate the strain by introduction into other fishless trout habitats in northeastern Nevada. Possibly it is the only surviving pure representative of the original subspecies native to Utah west of the Wasatch Mountains.

Sincerely,

18.5  
 Bob

Robert R. Miller  
 Curator of Fishes

RRM:mw  
 Enc. 2

N Pine Valley	N Lehman Crk
28 scales 135-156 193.8	2 x 148
21 above 37-44 40.1	2 42.0
28 vert 60-63 62.3	2 62.0
31 scales 19-23 21.5	2 20.5
31 basibranchial teeth 6-46 22.5	2

head l., upper jaw,  
 dorsal fin, caudal peduncle

STATE OF NEVADA  
FISH AND GAME DEPARTMENT

FRANK W. GROVES, DIRECTOR

Wheeler District  
P.O. Box 1109  
Ely, Nevada 89301

WHEELER DISTRICT

WILLIAM C. PARSONS, DISTRICT SUPERVISOR  
NEEDS: ST. NEVADA 89301  
PHONE: AREA 754-4101  
MAIL: BOX 1100

May 23, 1967

Dr. Robert R. Miller  
Curator of Fishes  
University Museums  
The University of Michigan  
Ann Arbor, Michigan

Dear Dr. Miller:

Once again I am writing to you in regards to the Utah cutthroat, S. c. utah. We are currently involved in a serological study of the small population here in Nevada. Preliminary reactions were quite uniform indicating that these specimens may be the pure strain. Further comparisons will be made with an out-bred strain of the Lahontan cutthroat, S. c. henshawi for additional substantiating evidence.

To our knowledge this small population, which you felt earlier to be a pure strain, is the only remnant of this species. Do you know of other possible populations? I am attempting to compile all available information on the history and decline of the species. I'm wondering if you could supply any information or references relative to its history, reasoning or theories responsible for its decline and general life history data. I had written to Gerald Smith as you suggested earlier, but have never received a response.

We hope to establish new populations in barren waters (barren of rainbow or cutthroat) in the future to perpetuate the species. I have written to Don Andriano, Chief of Fisheries, Utah Fish and Game Department for information pertaining to their early native habitat which would help us in reestablishing other populations. The nucleus population is currently so small that several years of successful transplants will be required to show any benefits.

Conservation Is Everybody's Job



Dr. Robert R. Miller

-2-

May 23, 1967

I will certainly appreciate any assistance that you can give toward this endeavor. I know you have shown a keen interest in this fish in the past.

Sincerely,

Dale V. Lockard, Fish & Game Agent II  
Nevada Fish & Game Department  
Wheeler District  
P.O. Box 1109  
Ely, Nevada 89301

DVL:gp

cc: Tom Trelease, Chief of Fisheries

June 2, 1967

Mr. Dale V. Lockard  
Nevada Fish and Game Department  
Wheeler District  
P. O. Box 1109  
Ely, Nevada 89301

Dear Mr. Lockard:

Thank you for your letter of May 23 regarding the pure strain of the cutthroat trout from Spring Valley.

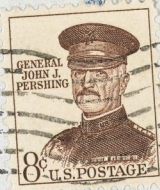
I am sending a copy of your letter to Dr. Robert J. Behnke (Colorado Co-operative Fishery Unit, Colorado State University, Fort Collins, Colorado 80521), who has recently prepared with the late Paul Needham a detailed account of the cutthroat trout in western North America. He is actively studying the races and subspecies of this fish, and I think he can do more to help you now than I can.

The Utah cutthroat trout was enormously abundant in Utah Lake before the turn of the century and perhaps was eradicated there by over-fishing or at least the population was cut to such a low level that subsequent ecological changes (including introduction of exotics) could have finished them off. The following pertinent quotation is taken from the paper by Cope and Yarrow (1875, Rept. Geog. and Geol. Expl. and Surv. W. 100th Meridian, Vol. 5, pp. 685-693):

"In comparison with the other fishes of Utah, the Lake Trout is undoubtedly the most numerous and the most easily captured; how long, however, this condition of affairs will last it is impossible to say, the supply having greatly diminished during the past few years, owing to the reckless methods of fishing and increase in the number of fishermen; moreover, a larger demand is now made for this fish, owing to increase in the number of settlers. The decrease in the yield may be roughly estimated at about one-third, but this percentage is slowly but surely increasing. The greatest size this fish attains, as far as could be learned on inquiry and from personal observation, is three feet; weight about fifteen and a half pounds. The average length, however, is about fourteen inches and average weight one and a half pounds. The rate of growth is not known, although it is stated by the fishermen to be perhaps an inch per annum, but according to my belief the rate is greater. The fish is supposed to attain its full size in about five years. In shape there is very little difference between the male and female; though near the breeding season the female is the larger and more brilliant in color."

These authors called the Utah cutthroat trout Salmo virginalis and used the common name of "lake trout". This is a very interesting account and

R. R. Miller  
THE UNIVERSITY OF MICHIGAN  
MUSEUM OF ZOOLOGY  
ANN ARBOR, MICHIGAN, U. S. A.



VIA AIR MAIL

Mr. Robert Behnke  
Department of Zoology  
University of California  
Berkeley 4, California

UNIVERSITY MUSEUMS  
THE UNIVERSITY OF MICHIGAN  
ANN ARBOR, MICHIGAN, U.S.A.

MUSEUM OF ZOOLOGY

September 11, 1964

Mr. Robert Behnke  
Department of Zoology  
University of California  
Berkeley 4, California

Dear Bob:

About a month ago we had a visit from Dr. J. D. Thomas of the University of Ghana who said that you have a fossil trout from California that you are working on. Since we have also been working on a fossil salmonid that was taken near Tulare, California, which seems to be identical to the one from Oregon, I am wondering if we may both be working on the same animal? Ted Uyeno started work on this fish but he went back to Japan over a year ago. In January of this year he was replaced as Research Associate on my fossil fish grant by Dr. Ted Cavender who took his Ph.D. in paleozoology at the University of Chicago. The salmonid we have was a huge fish larger by far than any known species of Oncorhynchus. The vertebrae are about the size of silver dollars.

We will be interested to hear what your critter is like.

Under separate cover I am mailing you a copy of the check list of Arizona fishes that Chuck Lowe and I published on in The Vertebrates of Arizona. The account of the Arizona native trout was written about three years prior to publication, and the paper was in press for an interminable length of time.

What is the current status of the manuscript by you and Dr. Needham? I almost finished taking all the data I need to describe the Arizona native trout but am caught in a bind now since Reeve Bailey is out of the country for two months.

Sincerely,

*Bob*

Robert R. Miller  
Curator of Fishes

RRM:mw

Zilliox, R.G. (1957)  
N.Y. State Conserv., 2(5):26-7  
New trout for none

Martin (1960) states, "General notes on planting in New York. Use in reclaimed waters. Combined plantings with rainbow trout."

Anon (1872)  
Ausland, 45:1104  
Ein neuer Bastard-Lachs (Salmo)

According to Dean (1962), miscellaneous and unimportant.

Anon (1952)  
North.Sportsman, 7(4):15, 27

According to Martin (1960), "Brief mention of Ontario Department of Lands and Forests and Canadian Wildlife Service hybridizing lake trout and brook trout."

Anon (1954)  
North.Sportsman, 9(2):15  
Splake hybrids

Martin (1960) states, "General comments on history and potential of hybrid. Popular account."

Anon (1957)  
North.Sportsman, 12(5):32  
"Splake" may be taken this year by angling

According to Martin (1960), "Short notes on limits, size, season."

Anon (1961)  
Wis.Conserv., 140:5  
Record splake

Anon (1961)  
Commer.Fish.Rev., 23(1):17  
Sixth species of salmon caught in Alaskan waters

Behnke, Koh, and Needham (1962) speculate that the Oncorhynchus masou caught could have been a Russian hybrid of O. keta X O. gorbuscha.

317 Anon (1962)  
Rep.Ont.Dep.Lands For.Res.Branch Sec.(Fish.), (44):61 p.  
Status of fisheries research projects for the year 1961

According to Regier (1966), J.S. Tait and F.E.J. Fry have worked on a selection programme to obtain a deep-swimming strain of splake.

318 Anon (1966)  
Mich.Conserv., 35(5):32  
Birth of the splake maybe?

319 F2 hybrids of Salvelinus namaycush ♀ X S. fontinalis ♂ in The First Annual Report of Fish Culture by Michigan's Fish Commissioners (1880)

Anon (1968)  
Rep.Freshwat.Biol.Assoc., (36):144 p.

According to Atz (1971), "Natural reciprocal hybrids of Salvelinus fontinalis and Salmo trutta."

320 Anon (1969)  
Fisherman, 32(26):12  
Scientists develop hybrid between Siberian and humpback salmon

321 Two photographs of hybrids of Oncorhynchus keta and O. gorbuscha developed at the Kalinin fish breeding plant on Sakhalin Island (USSR).

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## Alternative Taxonomic and Genetic Assessment Approaches in Managing Rare and Endangered Fishes

Don S. Proebstel  
Colorado State University  
World Salmonid Research Institute

Taxonomic and genetic evaluation of one form or another is commonly used to evaluate dwindling populations of native fishes. Typical questions commonly addressed include: determination of taxonomic purity; evaluation of genetic variability within and among populations; and investigations of phylogenetic and evolutionary relationships. Common methods include: classical taxonomic approaches such as morphological, meristic and osteological analysis; protein electrophoresis; and various DNA methodologies including restriction fragment length polymorphism (RFLP) analysis of mitochondrial DNA, nuclear DNA techniques such as micro-satellite and variable number tandem repeat (VNTR) loci, and direct sequencing of both nuclear and mitochondrial DNA. Advantages and limitations of various methods are discussed. Sampling considerations are important and with small populations non-lethal samples are often preferred. In most cases a combination of methods is optimal. Some types of genetic variability such as life-history or ecological uniqueness may not be amenable to genetic analysis, and, in general, a clear definition of purpose is essential to any genetic evaluation.

# **FOCUS OF QUESTIONS**

## **I. WHAT ARE THEY?**

**PURE/HYBRIDS**

## **II. GENETIC VARIABILITY**

**CONSERVATION**

**WITHIN POPULATIONS**

**AMONG POPULATIONS**

**ESUs what to preserve**

## **III. PHYLOGENETIC AND EVOLUTIONARY RELATIONSHIPS**

**Degrees of divergence**

**Species/ Subspecies/ Races**

# **METHODS IN MANAGING RARE AND ENDANGERED FISHES**

## **HISTORICAL PERSPECTIVE:**

### **I. MORPHOLOGICAL CHARACTERS**

Morphology/ Meristics/ osteology

### **II. MOLECULAR AND BIOCHEMICAL MARKERS**

**A. PROTEINS Electrophoresis**

**B. DNA Information**

**Tools for analysis:**

**RESTRICTION ENZYMES**

**SEQUENCE DATA**

**MITOCHONDRIAL DNA**



**Tools for analysis continued:**

**NUCLEAR DNA**

**MICRO SATELLITE,**

**VARIABLE NUMBER TANDEM  
REPEATS (VNTR)**

**RIBOSOMAL DNA**

**DNA-DNA HYBRIDIZATIONS**

**RAPD-PCR**

**INTRONS AND EXONS**

**Non-coding DNA**

**Box 4.2. Levels of Evolutionary Divergence at Which Various Molecular Genetic Methods Normally Provide Informative Phylogenetic Markers (Modified from Hillis and Moritz, 1990).**

Hierarchical Level	Protein Immunology	Protein Electrophoresis	DNA-DNA Hybridization	RFLP Analyses of			DNA Sequencing
				mtDNA	scnDNA	VNTR Loci	
Genetic identity/ nonidentity	—	*	—	*	*	**	*
Parentage	—	*	—	*	**	**	*
Conspecific populations	—	**	—	**	**	*	*
Closely related species	*	**	*	*	*	—	*
Intermediate taxonomic levels	**	*	**	—	—	—	**
Deep separations (>50 mya)	*	—	*	—	—	—	**

(\*\*)—highly informative; (\*)—marginally informative, but not an ideal approach for reasons of cost-ineffectiveness or other difficulties; (—)—inappropriate use of method. Not all categorizations are absolute. For example, some isozyme characters such as presence/absence of duplicate gene products can be useful at higher taxonomic levels.

**CONFLICTS, CONTROVERSIES AND  
DEBATES:**

**I. MOLECULES VS MORPHOLOGY**

**II. MOLECULES VS MOLECULES**

**III. CONSTANCY OF EVOLUTIONARY  
RATES**

**MOLECULAR CLOCK?**

**IV. NEUTRALITY OF BIOCHEMICAL AND  
DNA POLYMORPHISMS**

**V. HOMOLOGY VS SIMILARITY**

**ORTHOLOGOUS CHARACTERS**

**(DOLLO'S PRINCIPLE)**

**THE UNSAMPLED GENETICALLY BASED**  
**VARIABILITY**

**PHYSIOLOGICAL**

**ECOLOGICAL**

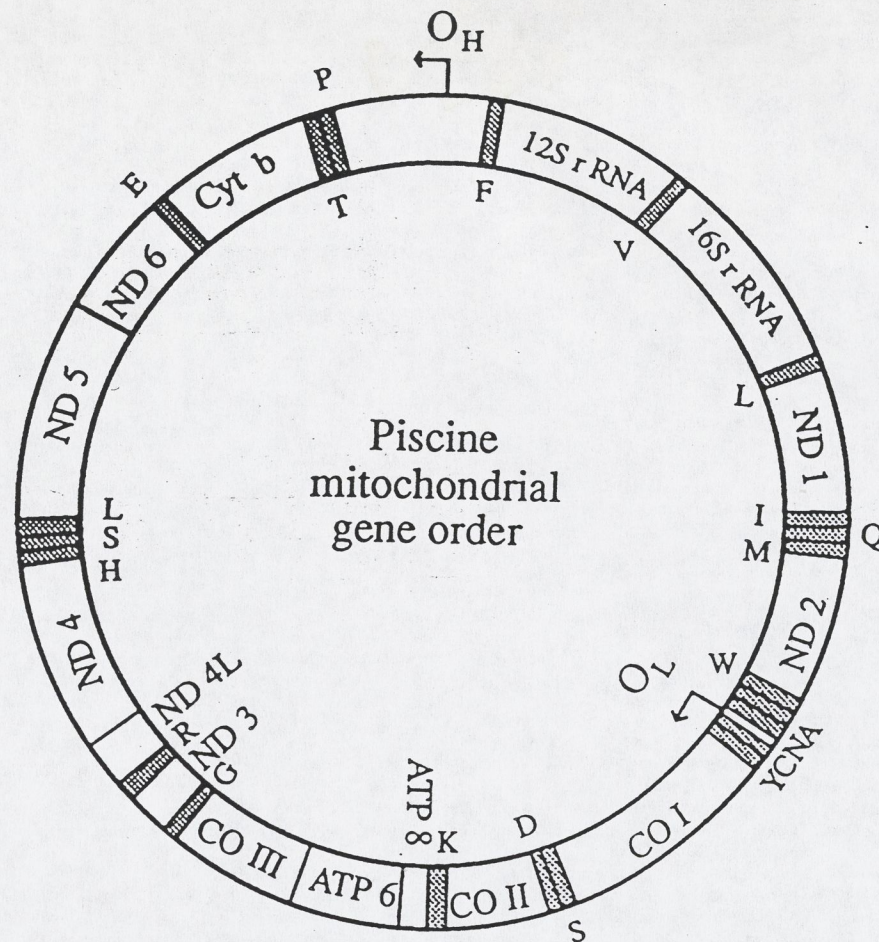
**BEHAVIORAL**

**LIFE HISTORY**

**EXAMPLES**

AND Summary

# MITOCHONDRIAL DNA



Mitochondrial DNA (mtDNA) is a Double stranded molecule with 13 genes coding for proteins, two genes coding for ribosomal RNA's (small 12S and large 16S), 22 genes coding for transfer RNAs (tRNAs) and one major non-coding region (control region in vertebrates). Of all mitochondrial genes the control region, which contains the Displacement loop (D-loop), has the highest substitution rate. Transfer RNA genes are shown in shaded boxes. The Origin of the heavy strand  $O_H$  is in the control region and the origin of the light strand  $O_L$  is in a tRNA gene cluster. (Meyer, 1993)

NA Dehydrogenase 3