# PETER HOCHACHKA

## ROOTS & BRANCHES

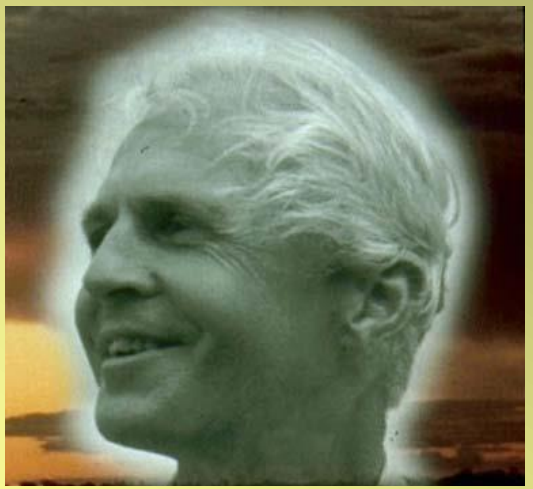
**Peter's scientific excursions into how animals deal with their environment inspired other labs around the world to take up his pioneering ideas and study the details of many specific systems. His insights brought integration to a vast field of comparative and medical research.**

# The Dawn of Comparative Physiology

**1865: Claude Bernard**

**"There are also experiments in which it is proper to choose certain animals which offer favorable anatomic arrangements or special susceptibility to certain influences. This is so important that the solution to a physiological or pathological problem often depends solely on the appropriate choice of the animal for the experiment so as to make the result clear and searching."**

# Comparative Biochemistry Unfolds



1920: A. Krogh ~ Nobel Prize

Mid-1900's ~ Viking Physiologists
P. Scholander
K. Schmidt-Nielsen
K. Johansen

A Canadian ~ F. Fry

Biochemistry ~ F. Lippman
H. Krebs
O. Warburg

Comparative Textbook ~ E. Baldwin

# Comparative Biochemistry

Enzymology

Metabolic Regulation

Comparative Physiology

Environmental Adaptation

Family, Alberta

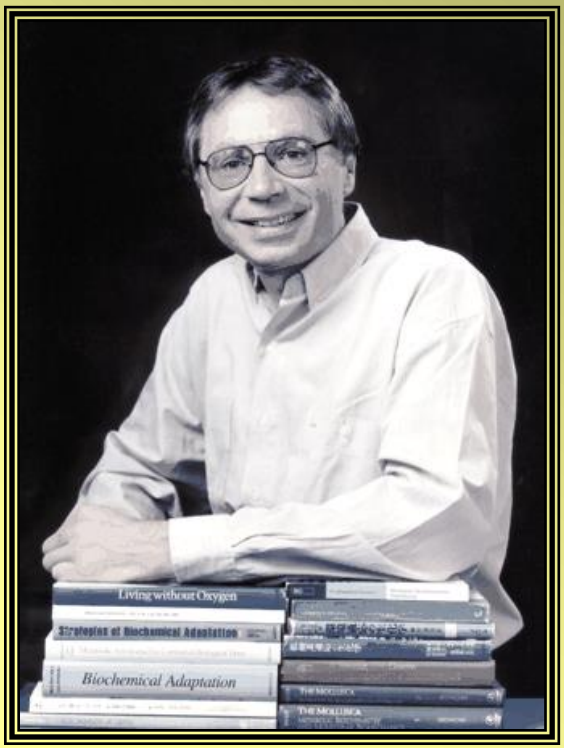
B. Clayton

Mentors

Alpha Helix

Intellectual Acquisitiveness

# THE WRITTEN RECORD
# Molecular Archeology




1) Publishing from 1961 - 2002
   * Publishing "Arc" virtually non-existent.
   * Started with Review Articles, Synthesis Chapters and Field-leading research contributions.

2) 1970 - 1980 114 papers
   1980 - 1990 98 papers
   1990 - 2000 113 papers
   * Science, Nature, PNAS, major journals of Biochemistry, Physiology, Comparative studies, Review Series, etc.

3) Over 200 collaborators as co- authors

4) Early Work 1970-1985 dominated by graduate student work
   Later (thru 1990's) more integrative: larger groups, collaborations

5) THE BOOK! ***Strategies of Biochemical Adaptation***
   * Right Place, Right Time
   * UNIQUE, VISIONARY (not compilation of data)
   * Synthetic → Drove investigations in the whole field

6) Oxygen-related studies → Central "Lake" of ideas to which Peter always returned

# PWH: The Published Record

**A. Fossil Hunting**

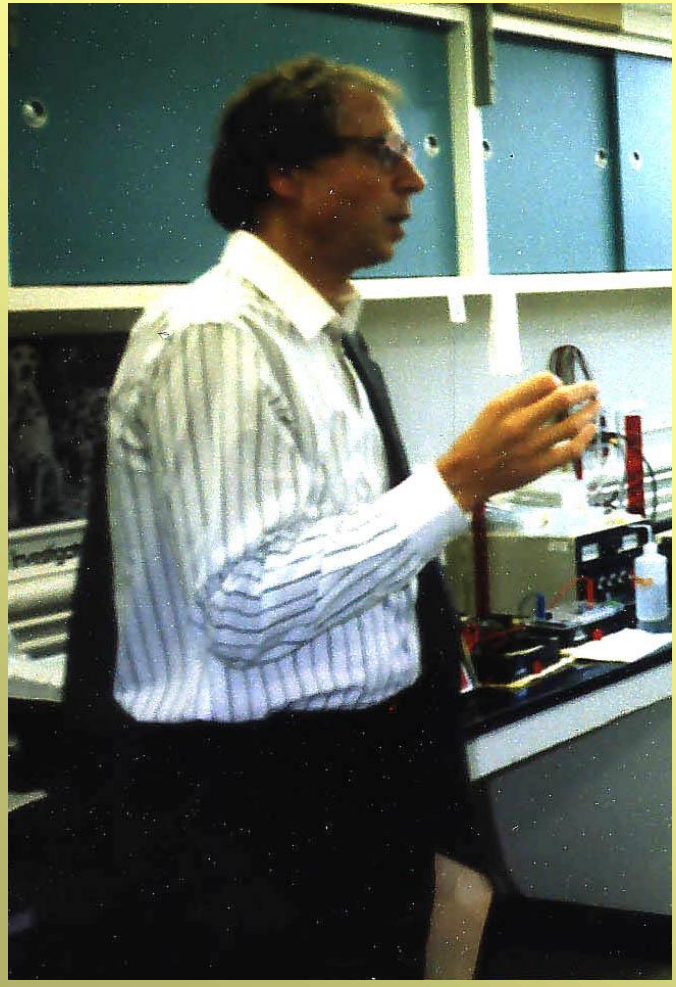
•Earliest papers - (1961) $O_2$ debt in fish
- CHO metabolism (aerobic) in lobsters
- Canadian Journals (Biochemistry, Zoology)!

•Era of temperature 1964 - 1970
- fish models (many species)
- blueprint for approach to metabolism set out

•Temperature paradigm abandoned ( l970-71)
- Framework of approach to metabolism/adaptation kept

•Brief Pressure Phase:
- Helix Galapagos
- Helix Hawaii

# PWH: The Published Record



**B. Era of Oxygen**

* Initial Approaches *

- Branch points: PEP branchpoint.
- Phospho-regulation (Oyster)
- Decreased metabolic rate (Turtle)
- Brain as Model (Turtle)
- Diving (Anoxia) (Turtle, Porpoise)

* Overall *

- Most studies were "informed by oxygen"

**C. Conceptual Parallels : l961 – 2002**

- Themes (Revisited)
- Frameworks (Expanded)
- Concepts (Elaborated Upon)

# THE SHADOWY BEGINNINGS OF $O_2$ STUDIES

THE BRAIN TRUST:

- PWH as BRAINS
- Starts with:

  4 JBC Articles

  2 Major Reviews

  2 Synthesis Articles in “Science”

---

ROLE OF ~ Models: Turtle on desk
Oyster in cold room
Dolphin in Vancouver aquarium

Helix: Amazon 1967
Galapagos 1969 - 70
Hawaii 1973

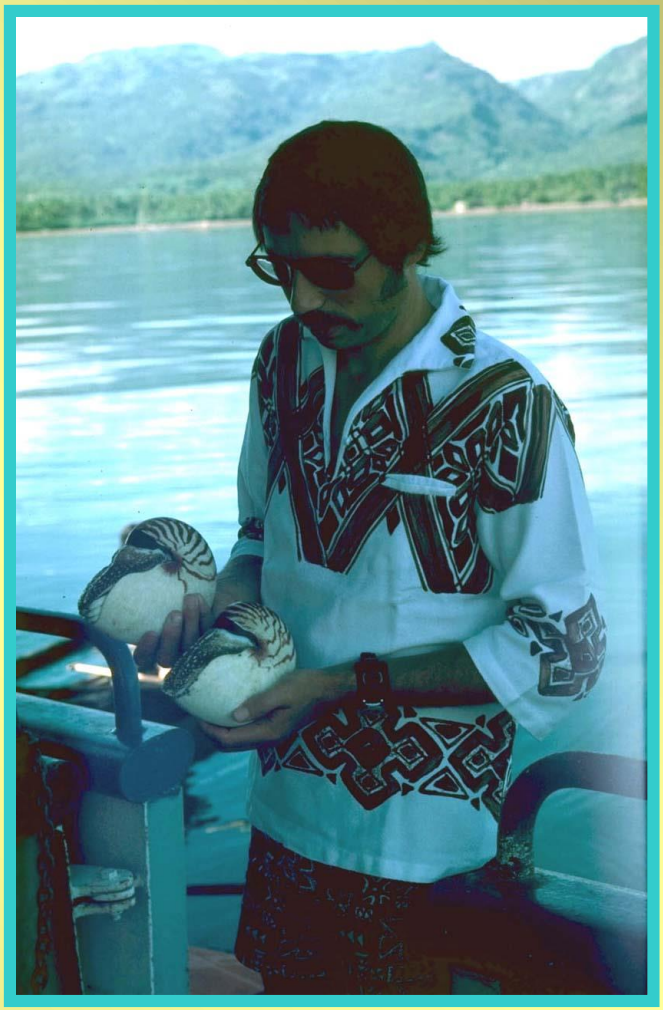
# THE HUGE EXPLOSION OF CREATIVITY & CHANGE IN EARLY - MID 70's

**A TEMPERATURE LAB SUDDENLY CHANGES**:

- Sudden "speciation"
  - Into Anoxia (oyster, turtle)
  - Into Pressure (cul-de-sac)
  - Into Diving ($O_2$ limitation)
  - Exercise ($O_2$ and anaerobic capacity)
  - High $O_2$ (squid, bees)

- Maintenance of directions *emerging from* $O_2$ for rest of career:
  - Exercise (muscle metabolism, anaerobic scope)
  - Mitochondria ($O_2$ metabolism)
  - Diving (aerobic dives)
  - Metabolic Arrest (starts with anaerobic models)
  - High altitude (oxygen limitations)

- Expansion of areas from a single point source
  - Conceptual Drives : 1970 – 2002



# Hypoxia: The Models

- Turtles
- Oysters
- Porpoise (dive)
- Fish:
  - Air breathing
  - exercise
  - environ. hypoxia
- Squid (NOT !)
- Bees (NOT !)

- Nautilus
- Octopus
- Seals
- Goldfish
- Elite Athletes
- Highlanders
- Greyhounds
- Horses
- Lungfish
- Turtles

**REVIEWS**

1970s: Animal Models
1980s: Metabolic Arrest
1990s: Human & Animal Model Systems
2000s: Health, Disease

# THE "WHY" OF A CREATIVE BURST

Punctuated equilibrium

A. Synthetic Intuition
   * the PWH approach

B. Constancy of Concept

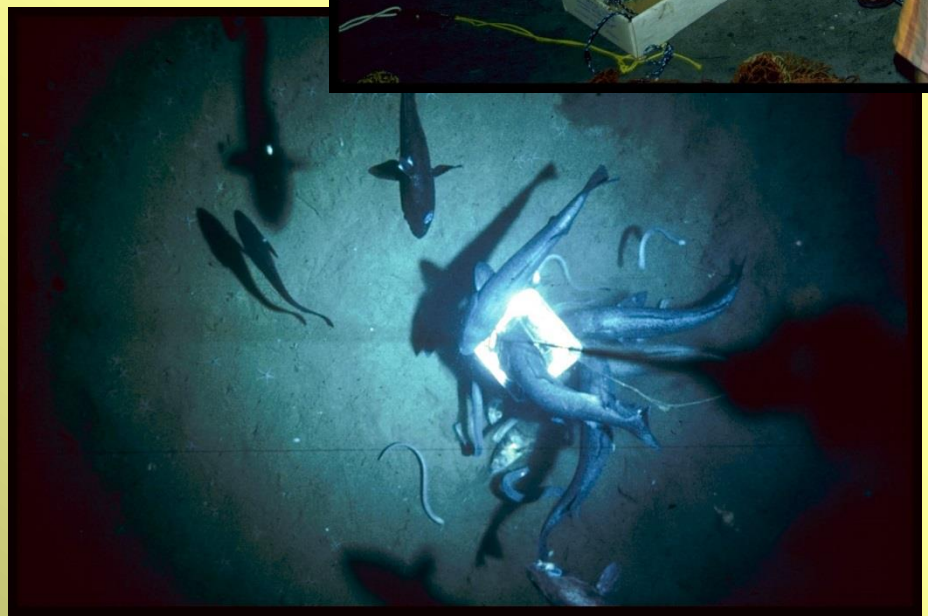
# SYNTHETIC INTUITION

**Something Old,**

**Something New,**

**Something Borrowed,**

**Some Glue.**



# SYNTHETIC INTUITION

FILTER

~ Transducer

~ Organizer

~ *Revamp*

~ IDEA LENS

IDEAS IN

~ Ecology

~ Physiol. Ecology

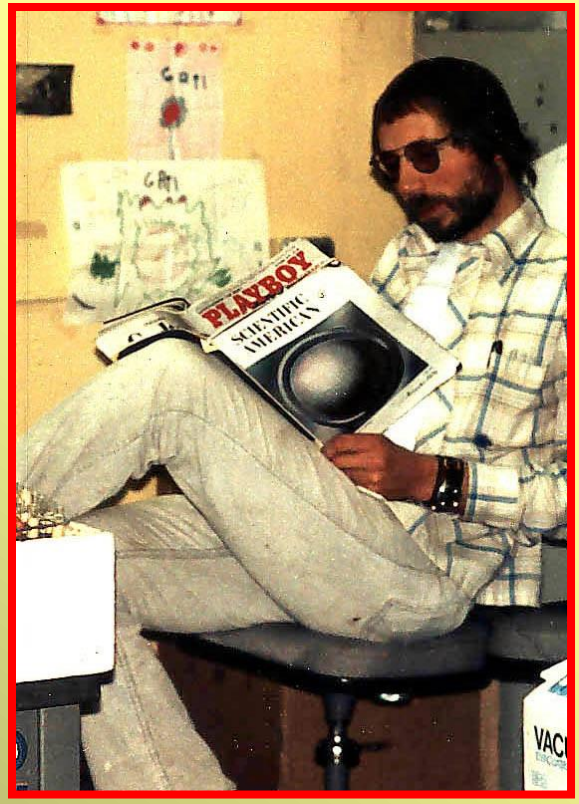
~ PHYSIOLOGY

~ Metabolism

~ Methods of Biochemistry

~ Molecular Biology

~ Genetics




IDEAS OUT

~ Metabolic Arrangement

~ Reorganization of Metabolism

~ Adaptive Change at Pathway Level

~ Integration: multi-levels of Biological Organization

# SYNTHETIC INTUITION COMPONENTS

IDEAS IN

~ Literature search
~ Helix
~ Visits to Colleagues
~ UBC itself
~ PHONE (1970)
~ EMAIL (1990)
~ Visitors
~ His own lab data
~ Student Excitement

TRANSDUCER COMPONENTS

~ IDEAS: PWH as throughput

~ DATA: His Work

* PWH work as "Model"

* PWH data "overturned"

~ COST-BENEFIT

* money (!)
* students
* collaborators
* teaching vs research
* university 'service'

OTHER

~ STABILITY of non-research life l970 onwards !

~ Excellent writing skills

~ NSERC-type $$

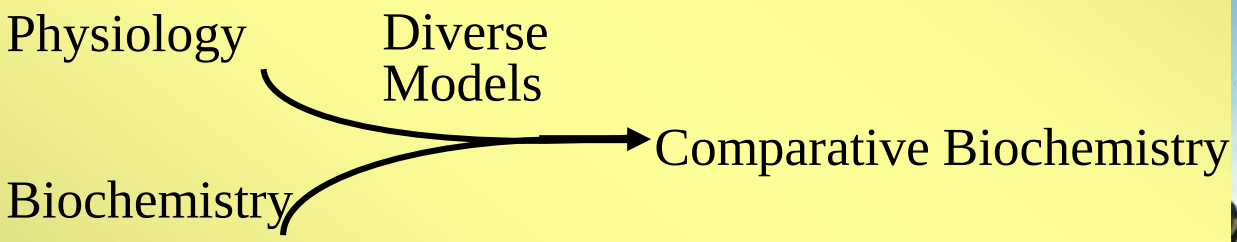
*Biggest fish in Canada

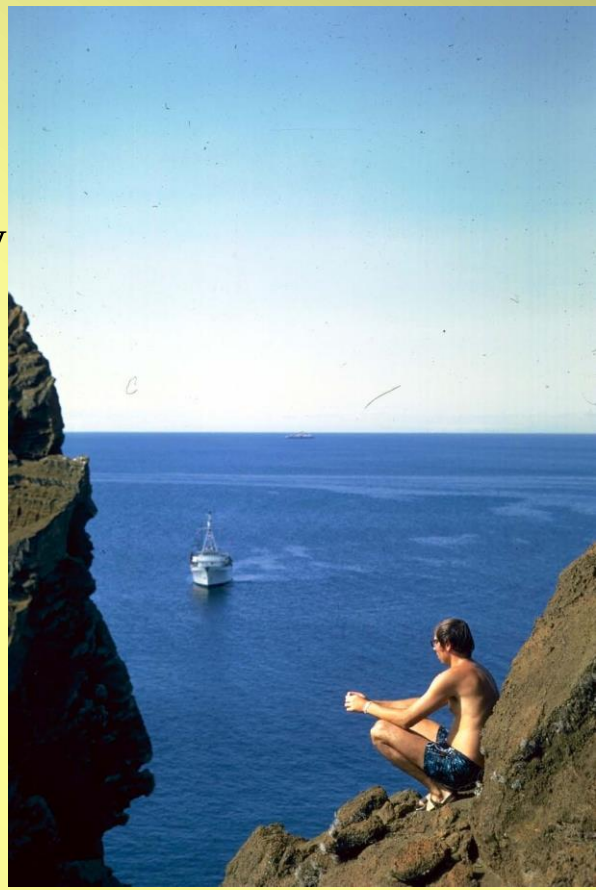
* THE BOOK !

~ Never "Circle the Wagons".

# SYNTHETIC INTUITION

1) A new mix of ideas leads to a new field:



2) Any new set of data reorganizes itself <u>through Peter</u> and returns as UNIQUE

3) Salvage Solutions from Chaos:
Hawaii: fish (NOT), Amazon,
Thesis Ideas, *DATA KNOTS*

4) Time Vampire: "Students Match Projects"

5) Ideas versus GOOD Ideas

6) Sink-or-Swim

# Student Wrangling

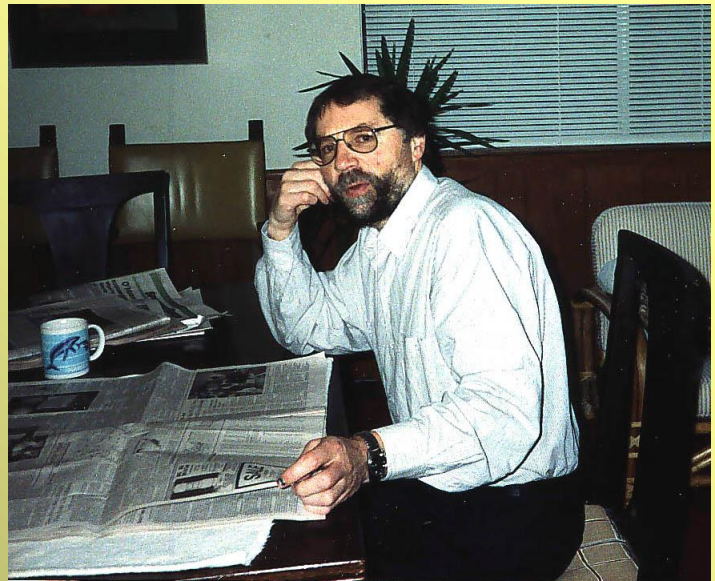
- I got PhD with 7th project I started
  Topics a) Temperature and tuna (!)
  b) Crabs and molting - *gluconeogenesis
  c) α-KGDH (regulate TCA cycle)
  d) DIVING: TURTLES (Porpoise)

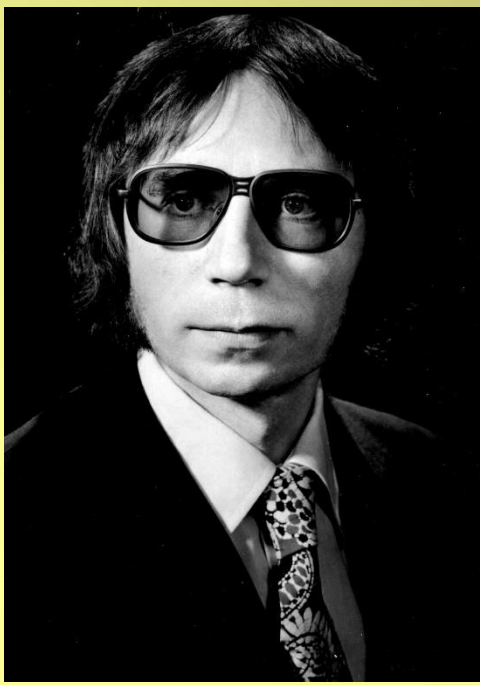
- He let me SINK / SWIM
- Thesis as 'minor' portion of SCIENCE done!
- Idea for final PhD: WRONG! Yet brilliant.
- I suggest crazy things: He said YES !!!!!!
- ~ bees, oyster, squid, porpoise
- Integration: "Optimize" student function.
  ~ diving review article
  ~ Helix trip although junior
  ~ Students work for THEMSELVES

# The Creative Burst: B

## Progression and Constancy

- Concepts, Approaches, Directions, Technologies -- all progressed 1960 ⟶ 2002
- There was a constancy of the "intellectual lens" through which Peter saw science





HUMANS

ANIMALS

METABOLIC ARREST

Air Breather

Anoxia Models

PRESSURE (Helix)

METABOLIC CONTROL (REDOX) 1961

TEMP as MODEL to 1970

$O_2$

Aerobic

DIVING

EXERCISE

High $O_2$

ELITE PERFORMANCE

squid

$O_2$ Limits

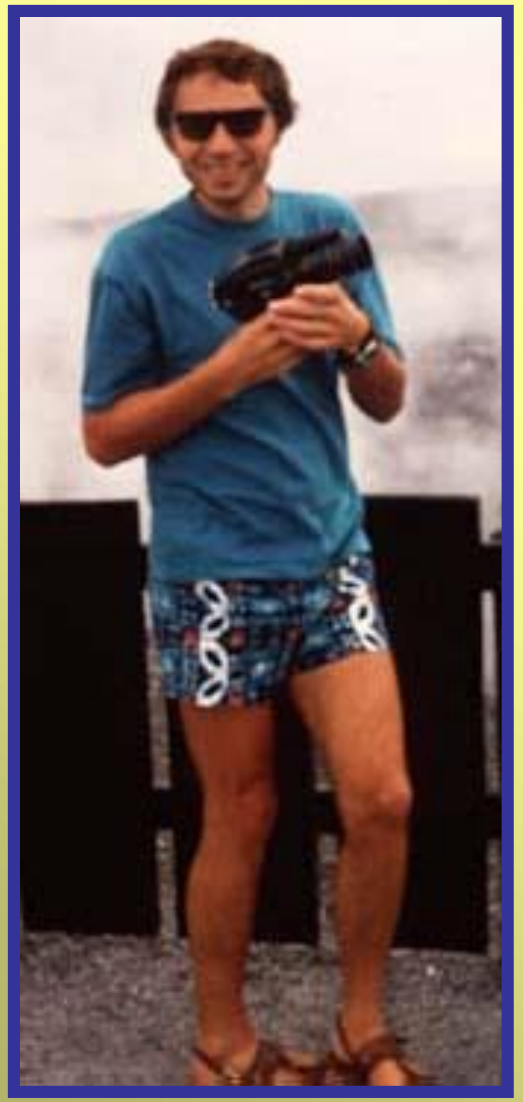
Mitochondria

HIF & Genes

HIGH ALTITUDE

HUMAN HEALTH

* 1970 - 1975: α Helix, BRENDA, Hawaii (sabbatical), Alaska, Baby Literature, Students



# MOLECULAR MECHANISMS OF TEMPERATURE ADAPTATION

A symposium presented at the Berkeley meeting of the American Association for the Advancement of Science 27–29 December 1965

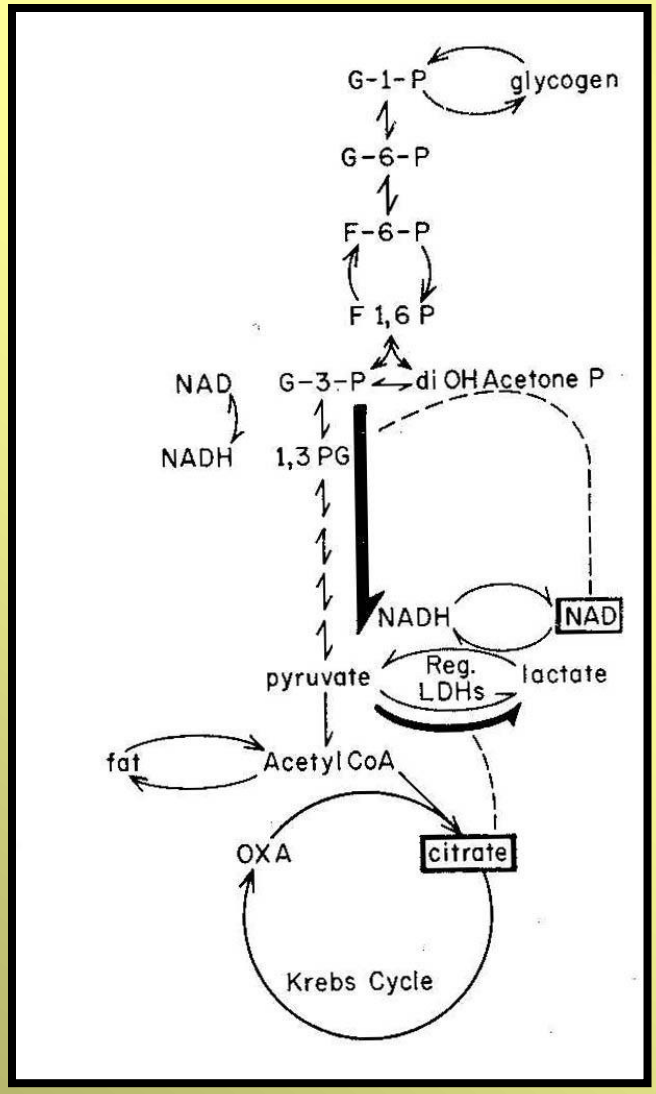
*Edited by*

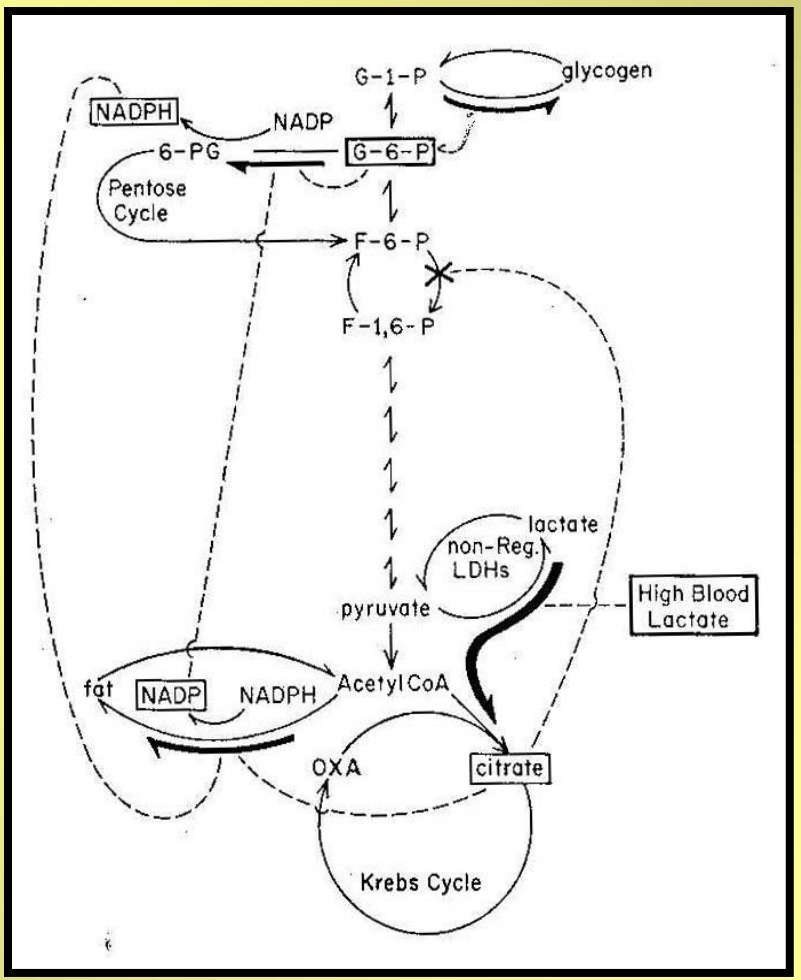
**C. LADD PROSSER**

## Organization of Metabolism during Temperature Compensation

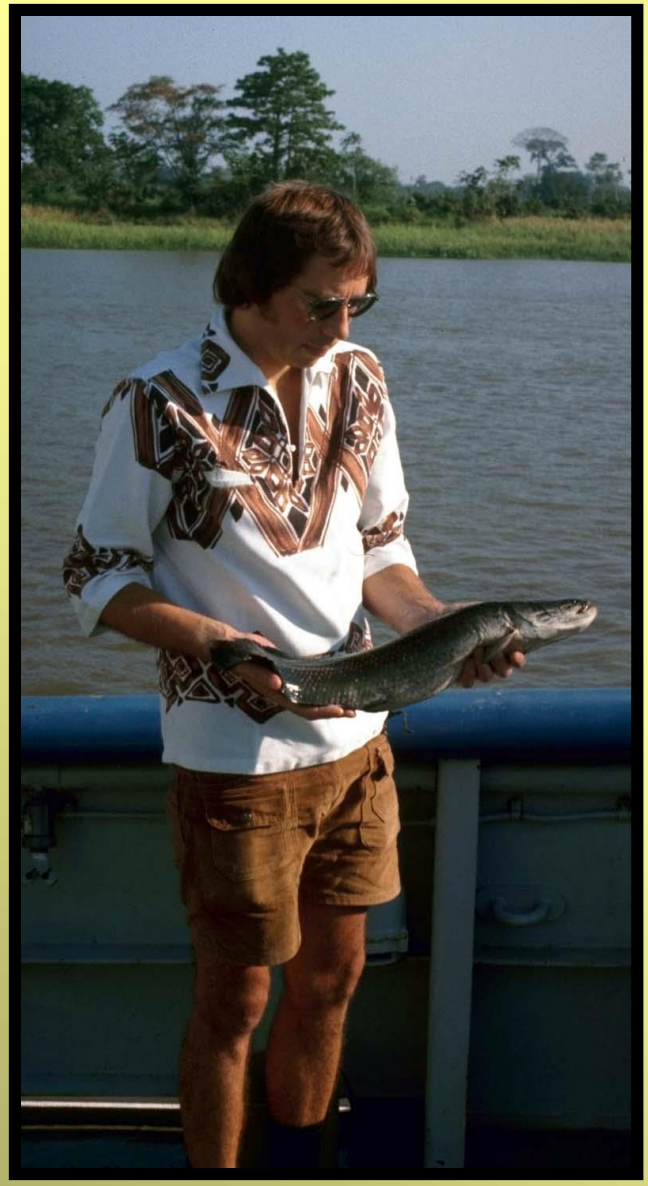
PETER W. HOCHACHKA

Often it has been stated that a living organism is, in large measure, a kind of bag filled with a concentrated mixture of many hundreds of different enzymes, and that each enzyme is a highly effective cata-


G-1-P
glycogen
G-6-P
F-6-P
F 1,6 P
NAD
G-3-P
di OH Acetone P
NADH
1,3 PG
NADH
NAD
pyruvate
Reg. LDHs
lactate
fat
Acetyl CoA
OXA
citrate
Krebs Cycle


G-1-P
glycogen
NADPH
NADP
6-PG
G-6-P
Pentose Cycle
F-6-P
F-1,6-P
lactate
non-Reg. LDHs
pyruvate
High Blood Lactate
fat
NADP
NADPH
Acetyl CoA
OXA
citrate
Krebs Cycle

**1961-1965**



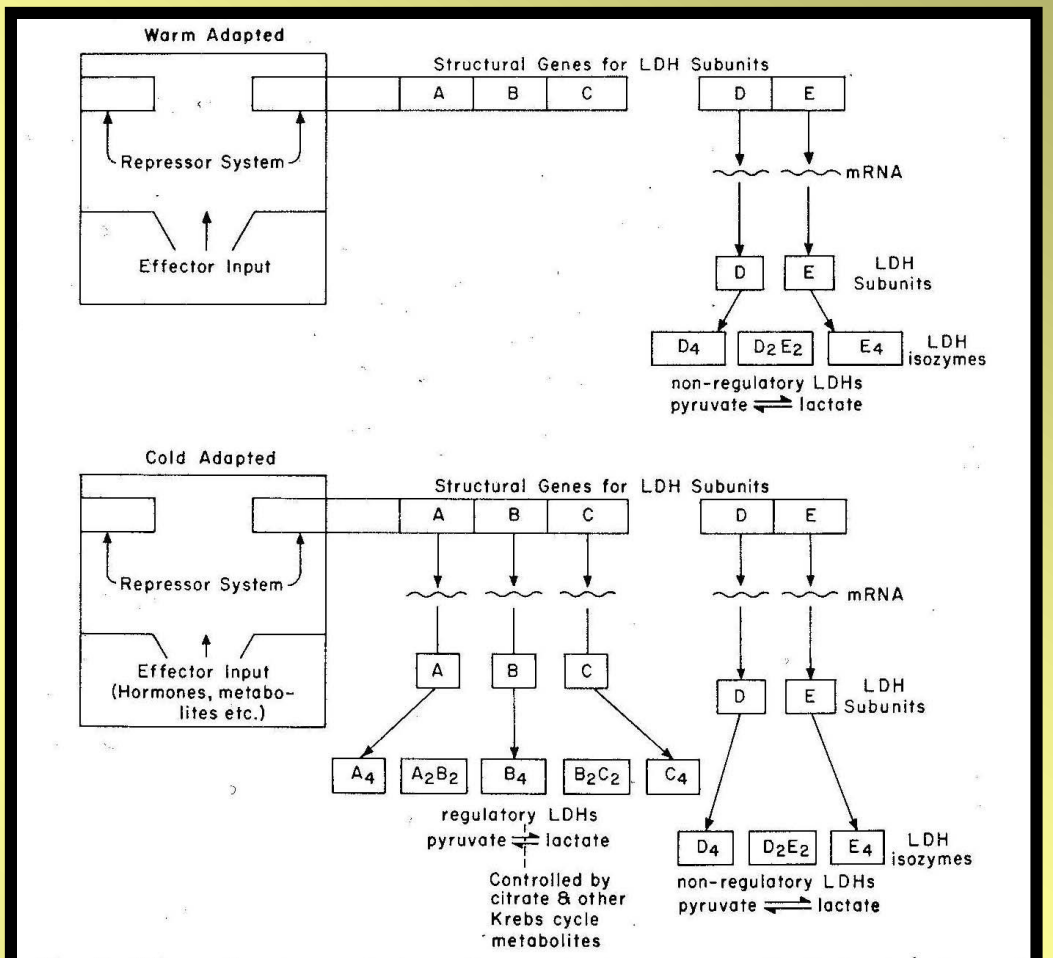


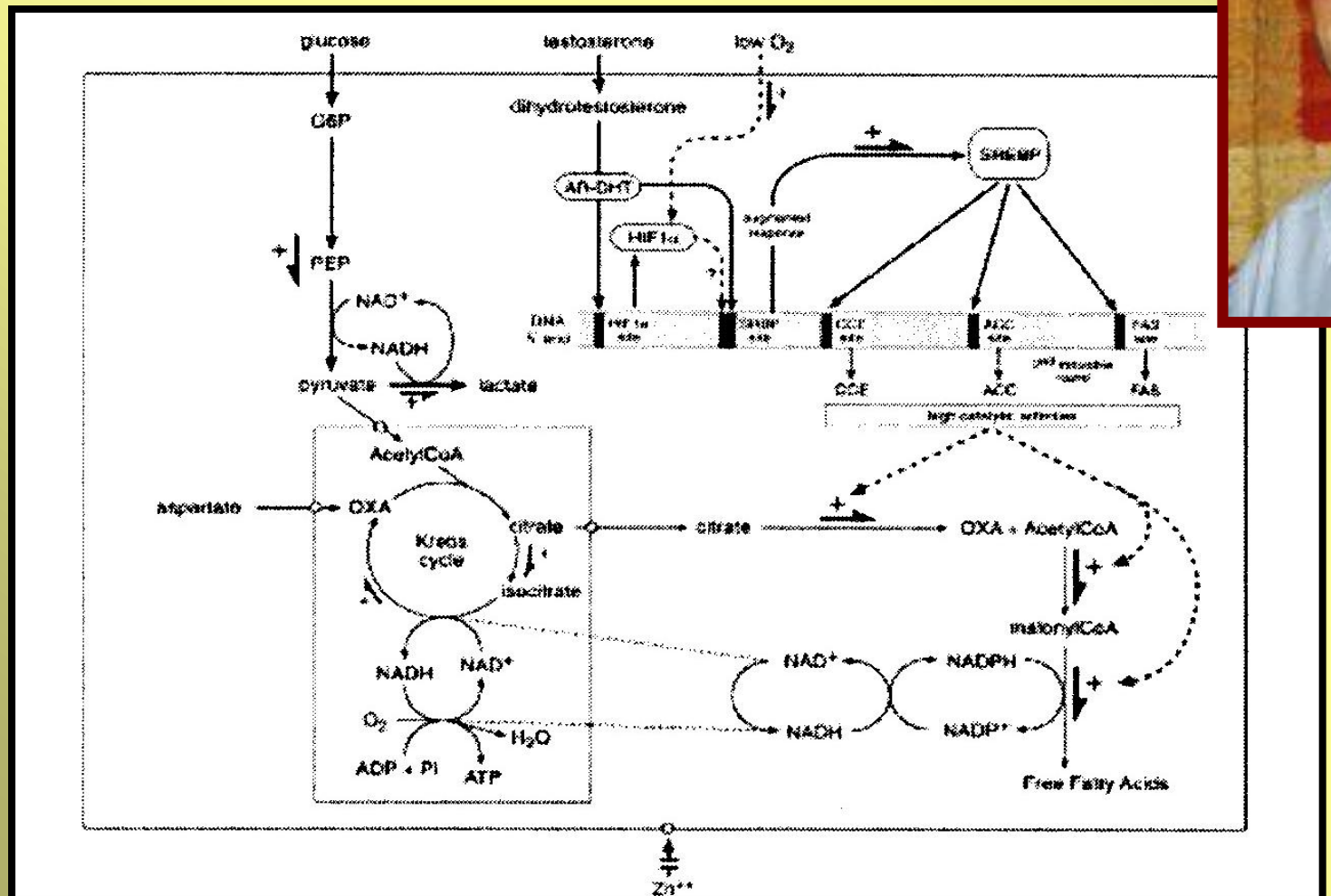

Fig. 7. Schematic representation of control of enzyme synthesis during thermal compensation. The repressor system on the left can be considered as a black box that regulates only one set of structural genes specifying LDH subunits. The control of another set (shown as the D-E system) is independent of the state of thermal compensation. The inducible LDH subunits assemble into LDHs that are regulatory. Not all of the isozymes formed are indicated in the diagram.

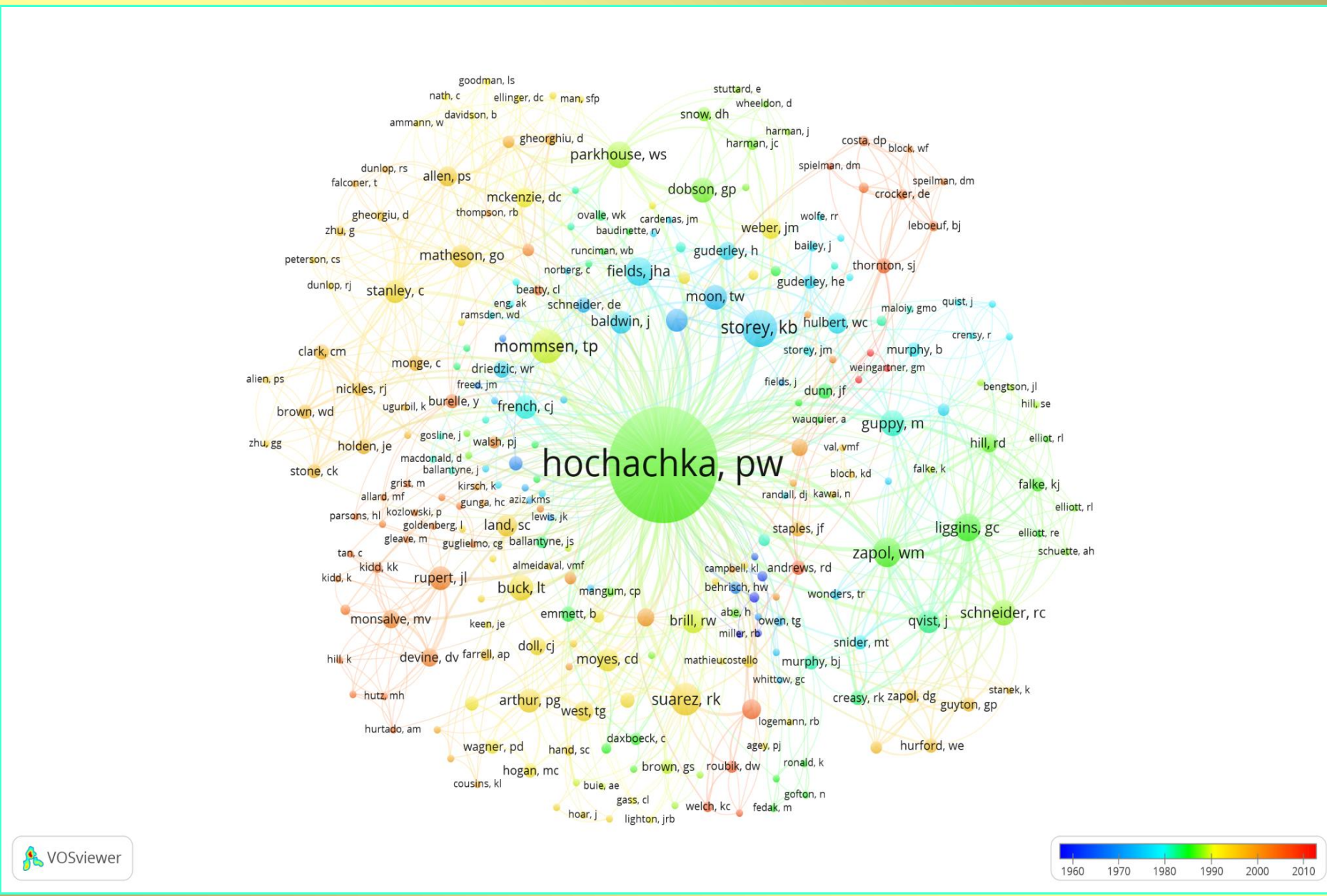
**1965**

# Going malignant: the hypoxia-cancer connection in the prostate

P.W. Hochachka, J.L. Rupert, L. Goldenberg,
M. Gleave, and P. Kozlowski

BioEssays 24: 749-757, 2002.






Made from 372 citations on Web of Science; compiled in VosViewer 1.6.5

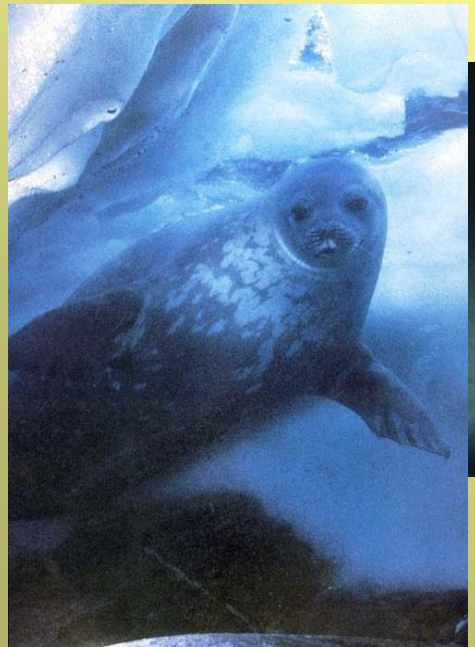
**PETER HOCHACHKA AND OXYGEN**

by K.B. Storey. 2003. In ***Hypoxia: Through the Lifecycle***. Adv. Exp. Med. Biol. 543: 331-337.

" The Hypoxia Society"

**ADVENTURES IN OXYGEN METABOLISM**

by K.B. Storey. 2004. ***Comp. Biochem. Physiol. B*** 139, 359–369



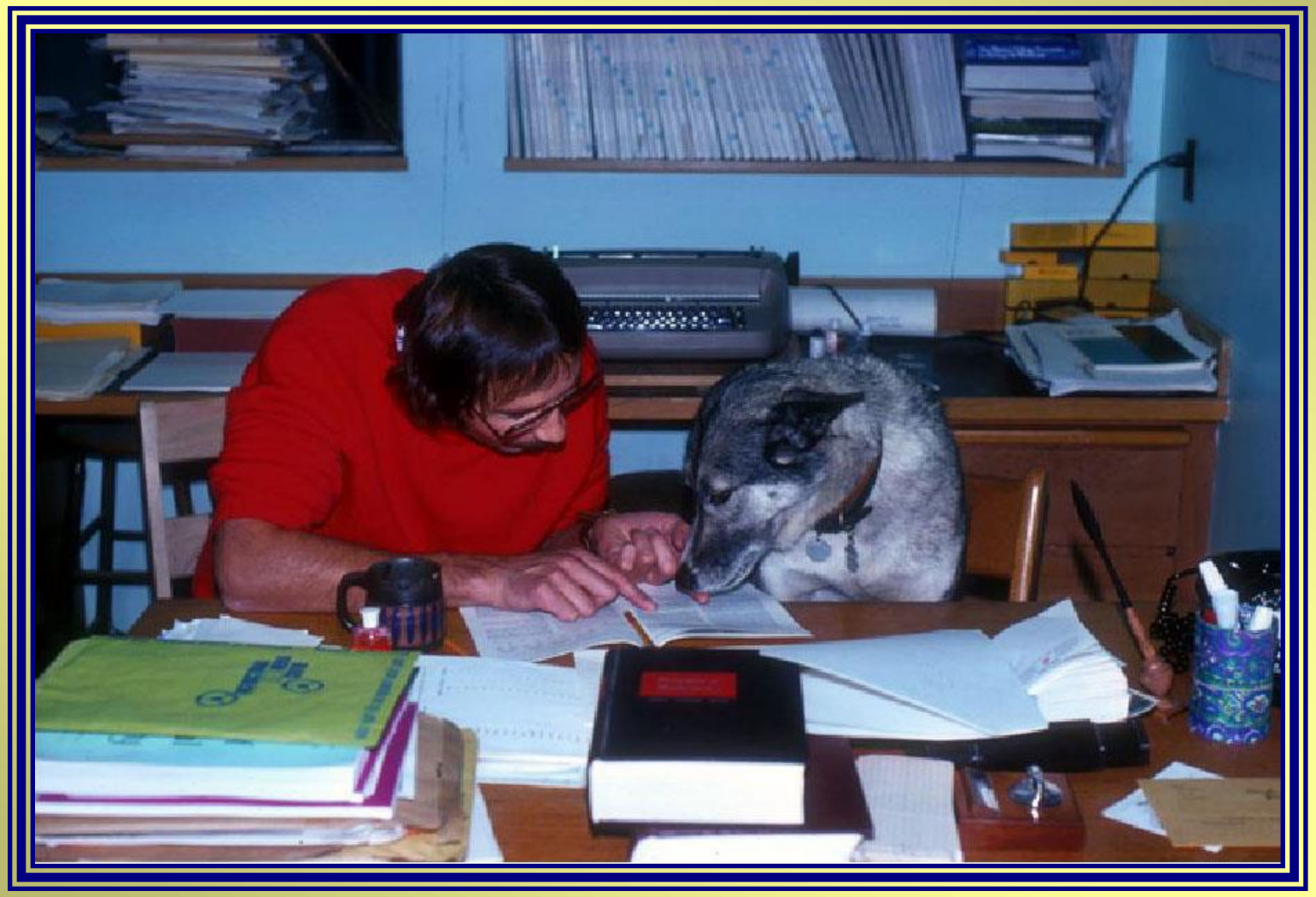
**The Scientist is not a person who gives the right answer,**
**He's the one who asks the right Question.**
-- C. Levi-Strausse

**A Science is any discipline in which the fool of this generation can go beyond the point reached by the genius of the last generation.**
-- Max Gluckman

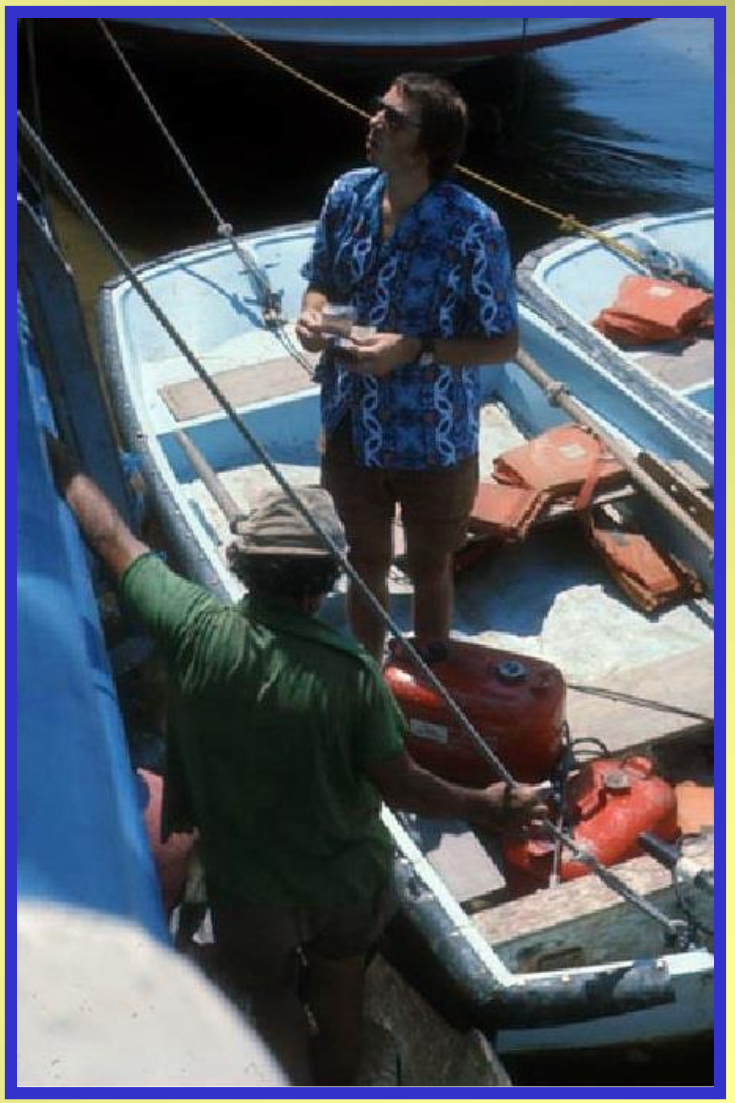
# WIT & WISDOM OF PWH

**Supervisors say the darndest things**

# Peter's Favorite Student



**Source of many "personal communications" ?**

“ *If you teach poorly enough for long enough, they stop asking*”

~ Advice to me as I headed off to Duke

# PWH: Finances

**“ My lab is full”**

>> Said to KBS when asked about taking Ken into his lab.

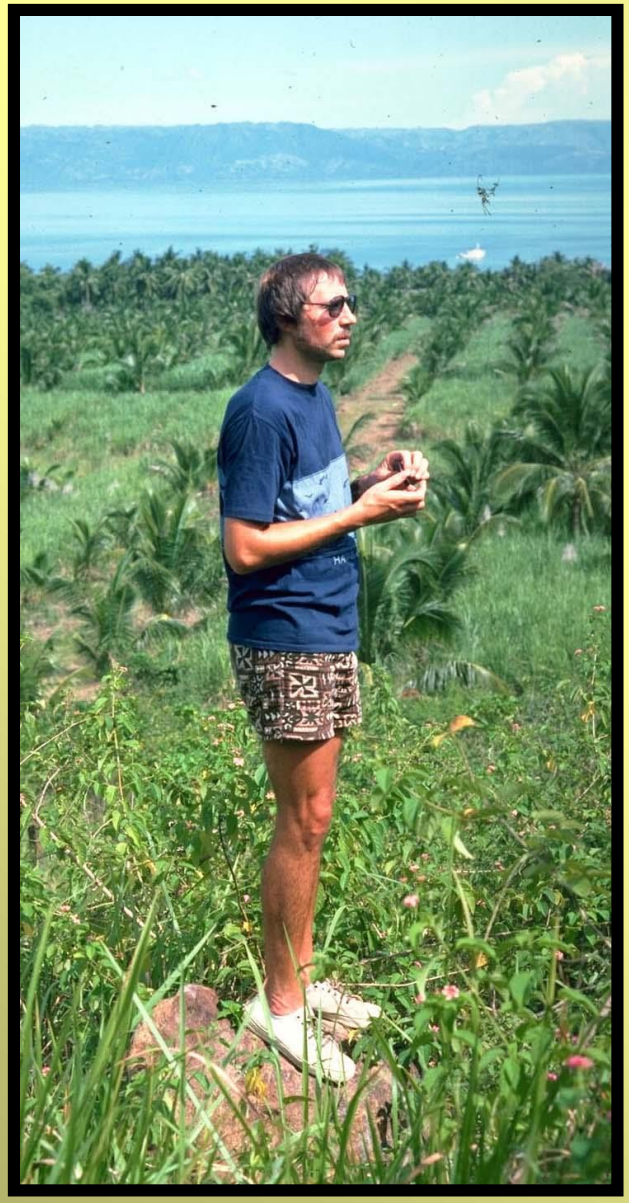
---*15 minutes of discussion later* --

**“ Take that desk”**

>> Said to KBS when Peter discovered that Ken had a scholarship that paid both salary and research expenses.

“ Very Interesting, very interesting”

--Peter,  dismissing an idea



"Unless you are the PACKLEADER the view never changes"

--Referring to non-*lead* dogs in a dog sled team.

“ They were the longest (two) years of my life”

-- Referring to the two years of Ken: 1972 - 1974

# Favourite Phrases

- Reptilian scales fell from my eyes
- Knuckle-draggers
- Like water off a duck's back

# A Life of Science Adventure

## Mentors

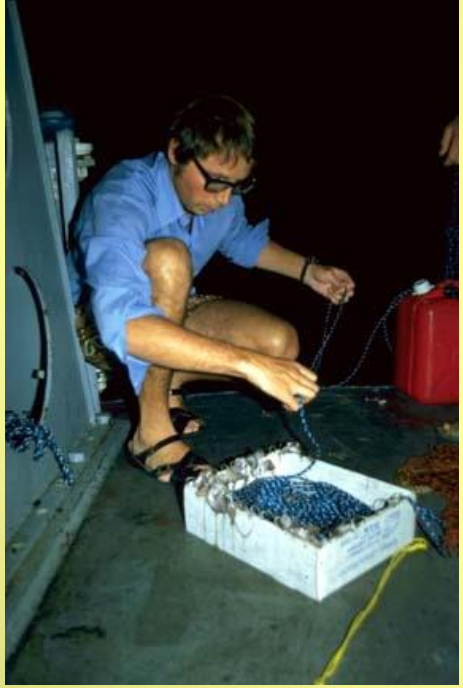
Peter Hochachka

Dave Jones

Knut Schmidt-Neilsen, Ladd Prosser, Kjell Johansen, UBC giants [ex. Bill Hoar], Fred Fry, Hans Krebs, A. Helix, Earl Stadtman, DUKE [Zoology], JM Teal, M Telfored

**DO YOUR WORK, THEN STEP BACK.**
**THE ONLY PATH TO SERENITY.**

**- “Tao Te Ching” by Lao Tzu**



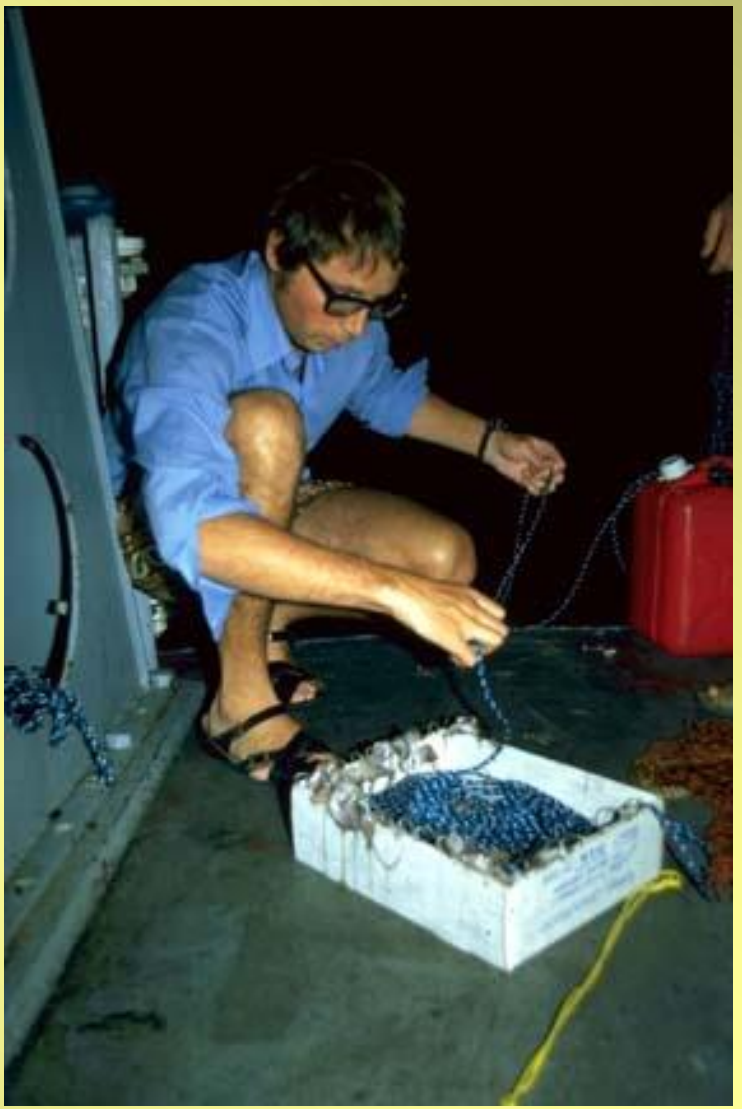

## Hawaii – Kona Expedition 1973

# Hawaii – an Alpha Helix tale

- Kona Coast
- 25 foot waves between islands
- Follow-Up trip to consolidate “wins”

# Hawaii

# Hawaii



# Biochemistry at Depth

## PRESSURE EFFECTS ON BIOCHEMICAL SYSTEMS OF ABYSSAL AND MIDWATER ORGANISMS: THE 1973 KONA EXPEDITION OF THE *ALPHA HELIX*

Edited and Organized

by

P. W. HOCHACHKA

Department of Zoology, University of British Columbia, Vancouver 8, Canada


*Comp. Biochem. Physiol. B 52(1), 1975*

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# And if you don't find fish.....

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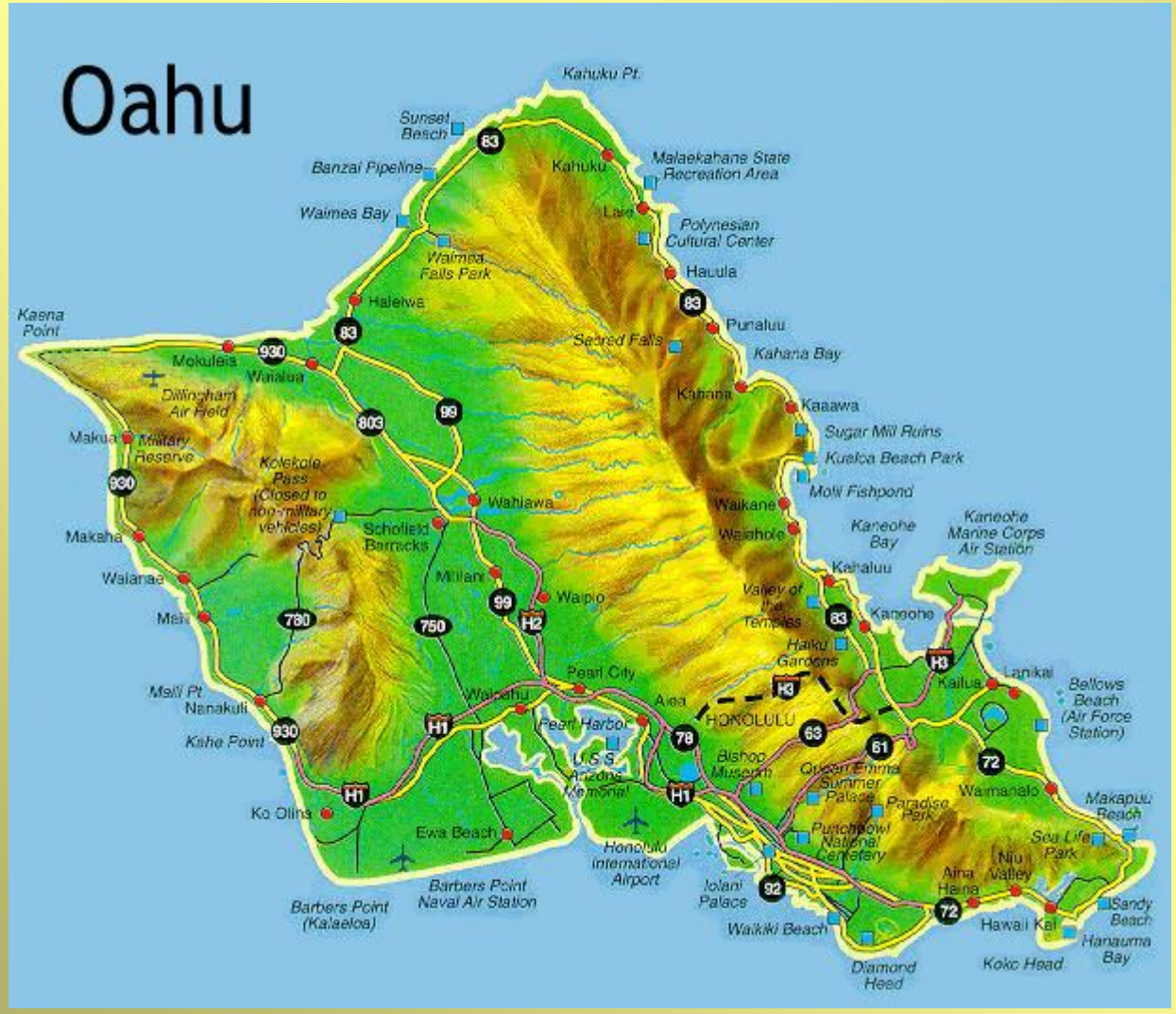
# Honolulu, 1975
# Kewalo Marine Lab
# Pacific Biosciences Research Center


Oahu
Kahuku Pt.
Sunset Beach
Banzai Pipeline
Waimea Bay
Kahuku
Malaekahana State Recreation Area
Laie
Polynesian Cultural Center
Waimea Falls Park
Hauula
Haleiwa
Punaluu
Kaena Point
Sacred Falls
Kahana Bay
Mokuleia
Waialua
Dillingham Air Field
Kahana
Kaaawa
Makua
Military Reserve
Sugar Mill Ruins
Kuaiola Beach Park
Kolekole Pass (Closed to non-military vehicles)
Wahiawa
Moli Fishpond
Waikane
Makaha
Schofield Barracks
Waiahole
Kaneohe Bay
Kaneohe Marine Corps Air Station
Waianae
Mililani
Kahaluu
Waipio
Valley of the Temples
Mili
Kaneohe
Haiku Gardens
Pearl City
Lanikai
Mili Pt
Nanakuli
Waiau
Aiea
HONOLULU
Bellows Beach (Air Force Station)
Kahe Point
Pearl Harbor
Kailua
Bishop Museum
U.S.S. Arizona Memorial
Queen Emma Summer Palace
Waimanalo
Makapuu Beach
Ko Olina
Paradise Park
Punchbowl National Cemetery
Sea Life Park
Ewa Beach
Honolulu International Airport
Aina Haina
Niu Valley
Barbers Point Naval Air Station
Iolani Palace
Barbers Point (Kalaeloa)
Waikiki Beach
Hawaii Kai
Sandy Beach
Diamond Head
Koko Head
Haraumia Bay


(North)
Waipio Valley
Kohala District
Kohala
Honokaa
Waimea
Hamakua District
(South)
Hilo District
Waikoloa
(North)
Mauna Kea
(North)
Kailua-Kona
Hualalai
Hilo
(South)
Kona District
Puna District
Mauna Loa
Pahoa
Captain Cook
Kilauea
(South)
Kau District
Hawaii Volcanoes National Park
Naalehu
Ka Lae (South Point)
Big Island (of Hawaii)

**Balancing**
- **Time away limited**
- **Family focus**

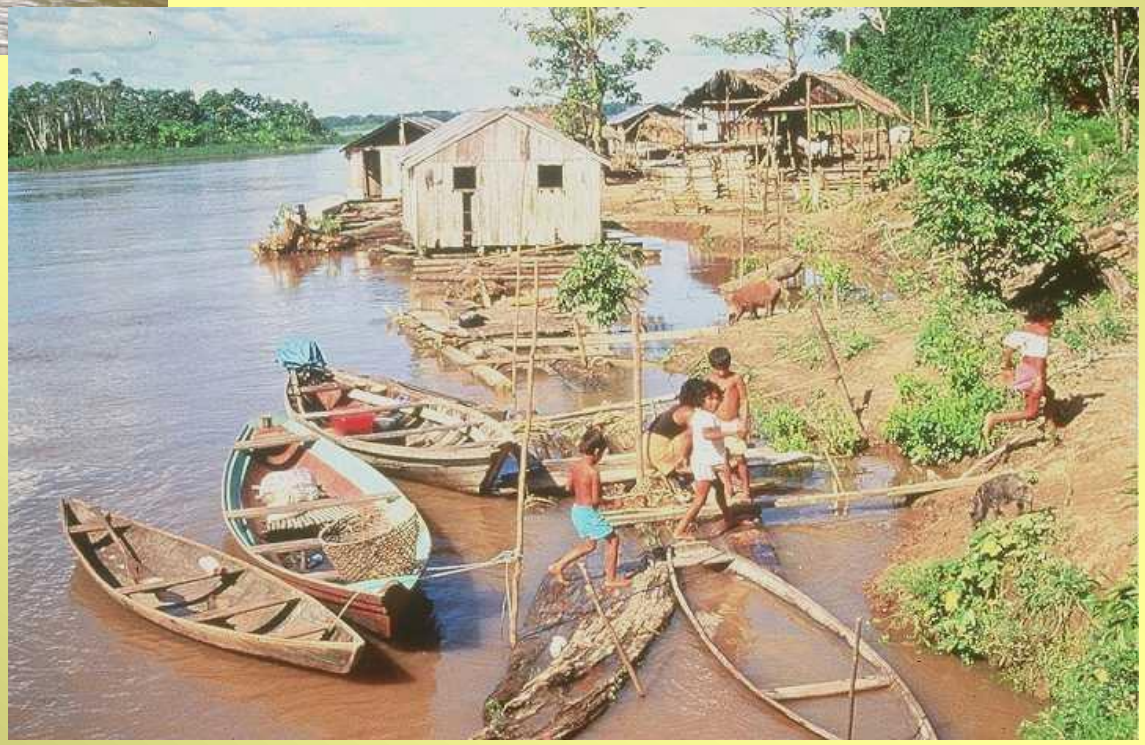

# The Helix:  Crucible

## Up the Amazon –
## Paddles did NOT help

- Rescued from the river
- Small boys & Fish
- Science in context
- Amazon connection
- Nature’s richness
- Peter’s projects have legs

- **Soccer with the kids**
- **Floating houses & pet pigs**

- **24/7 research.  Intense**
- **Longest day:  28 h → from animal to purified enzyme (1 band on SDS-PAGE)**

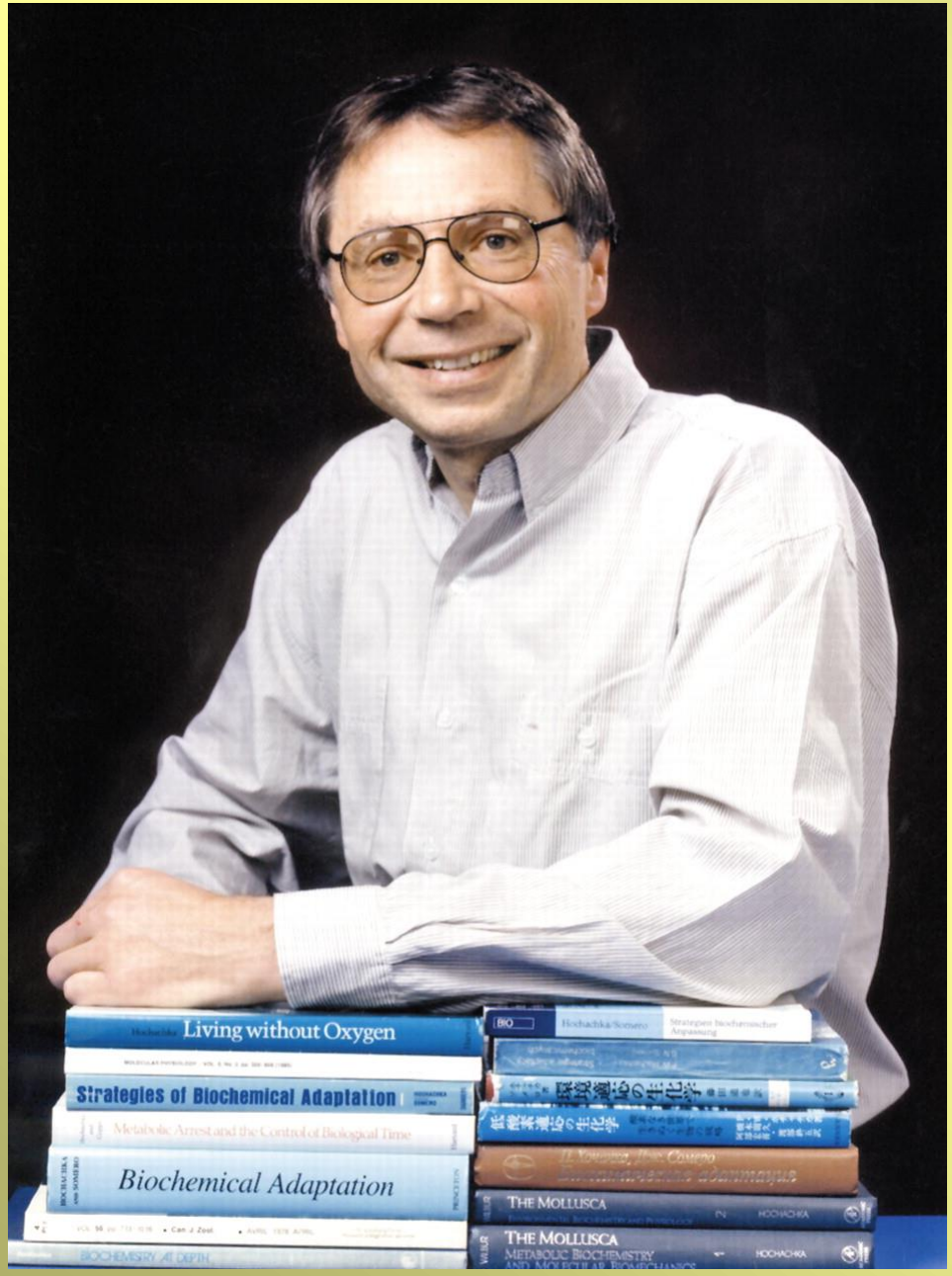


**No caimen were harmed**

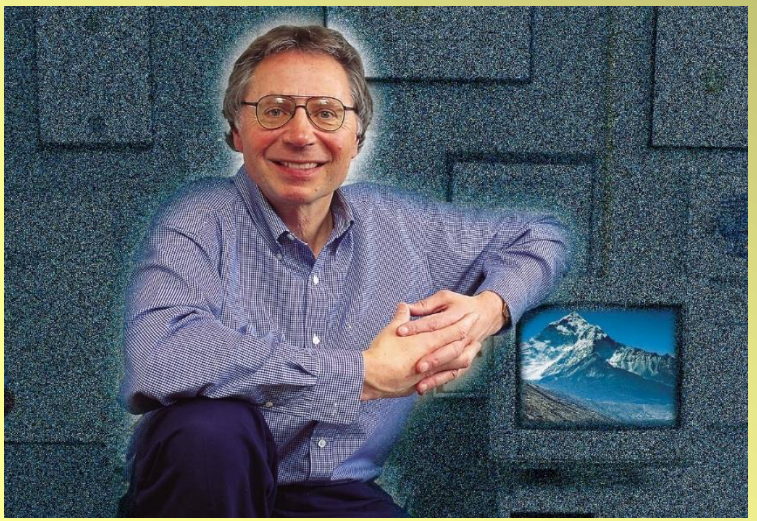

- **Electric eel delivered**
- **Babysitting the pirarucu**
- **Escape of the walking catfish**

**"Reptilian scales fell from my eyes" PWH**

**Several hundred pictures of the black vs white water taken !**



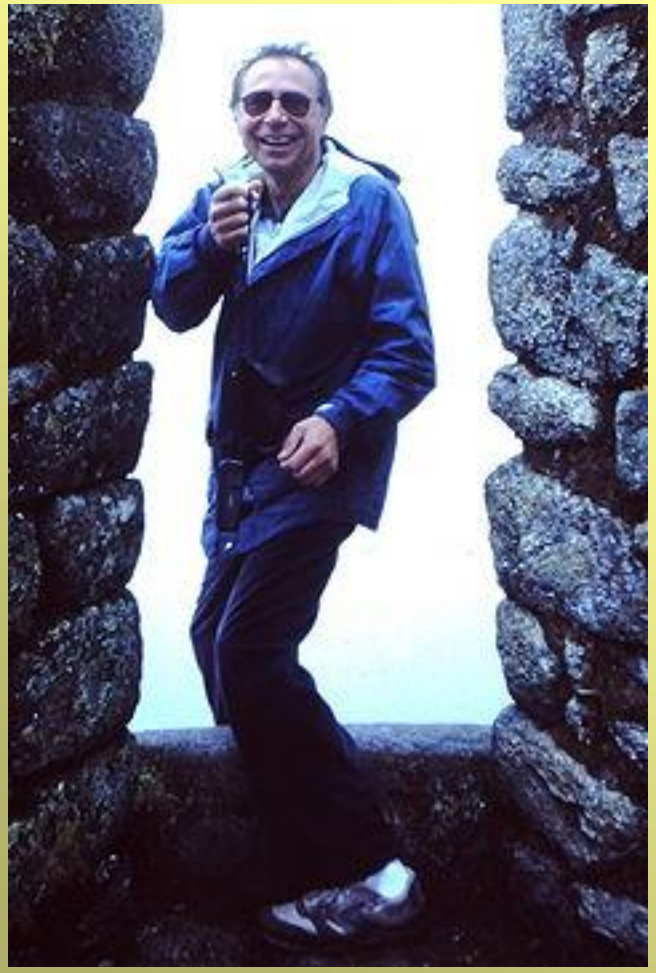

## Academic Accomplishment = job offers



## Two that I know of:
## U Victoria
## U Alberta

**The lead dog**

**Philosophical**



*** If I have to hold their hands now, how will they become independent scientists**

*** "Fas-SKIN-nating"**

*** UBC visitors – Nobels [Skou] & others**

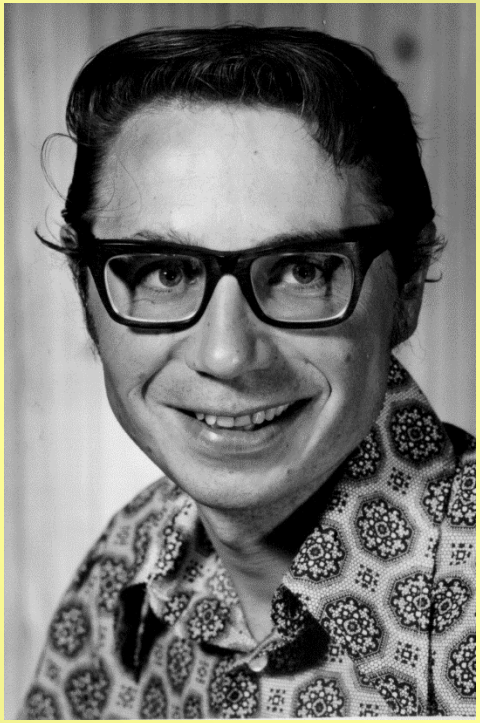
*** Field Trip Great Co-Scientists**

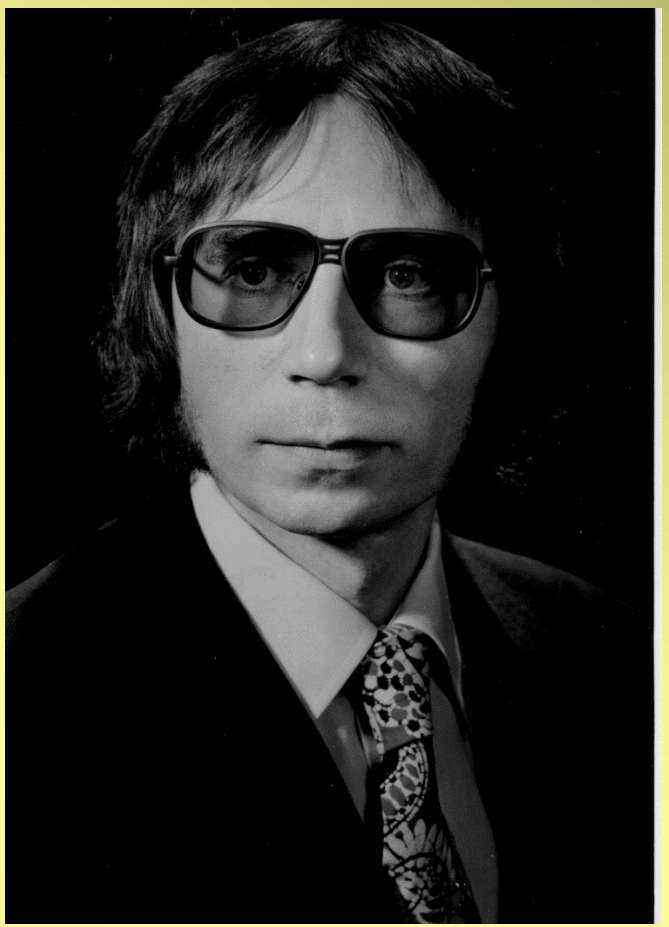
**- You inherit his friends. - You inherit his enemies**

*** My first external PhD external examiner wanted to fail my thesis. He 'went away'.**

**Ken, the tortoise, suddenly realizes that it is *NOT* going to turn out like in the fable**

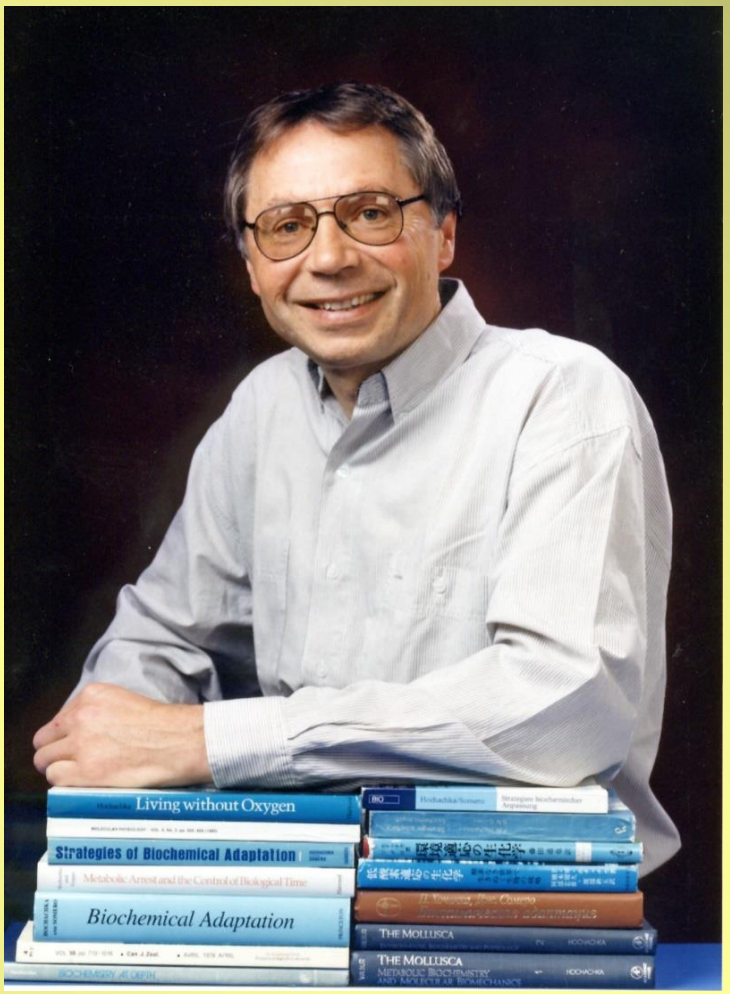
# Peter: Prankster



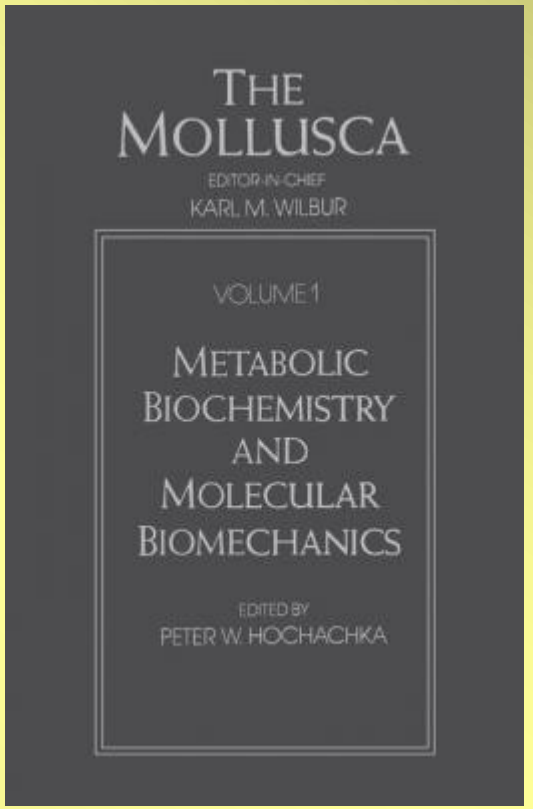


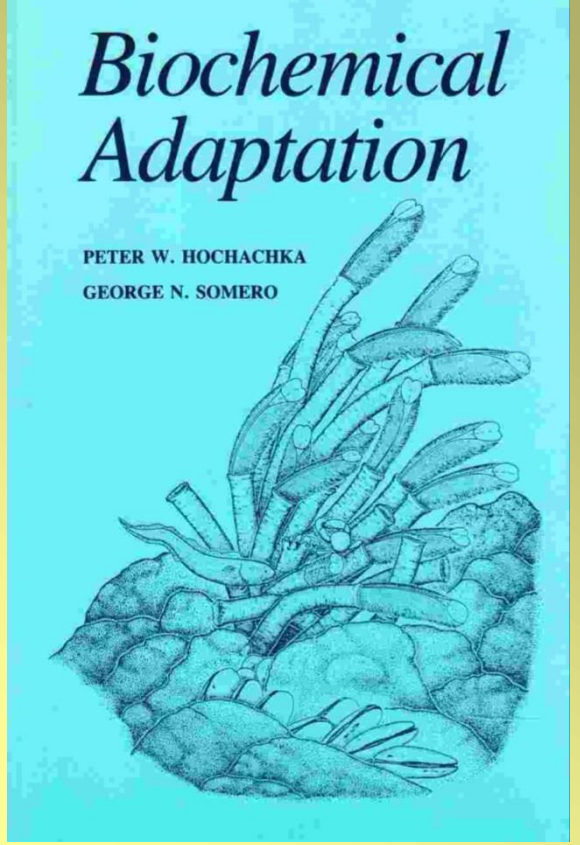
- **Woods Hole: GDH**
- **Eating the deep sea shrimp**
- **The lava, the data & the pancakes**

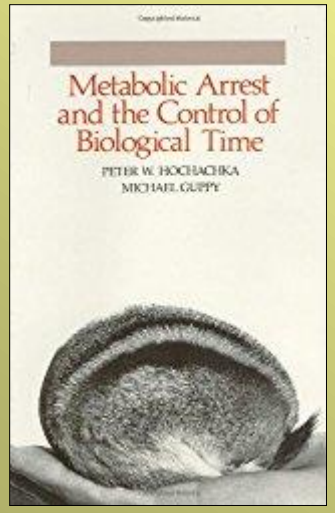

**My one R-rated Story: Ken and Peter walk into a bar……. Our fantasy**

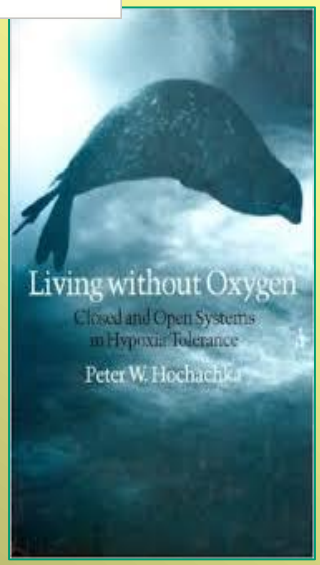




The first one elevated him into the stratosphere

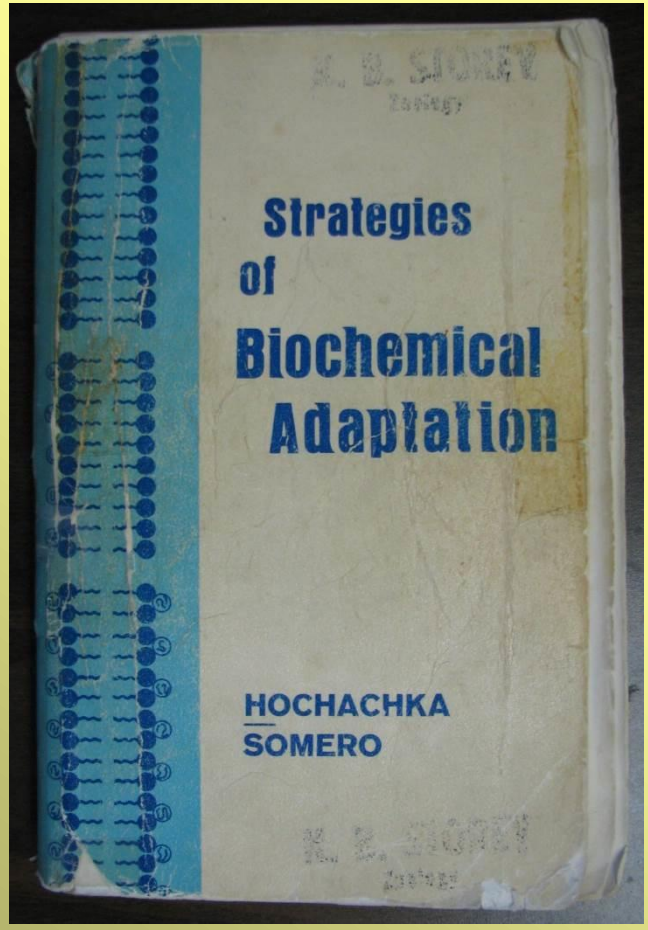

One Trial Writer:

Paper + Selectric + calling out to Jeremy for facts =

Lead article in science, grant propos book chapter.

~ Pristine

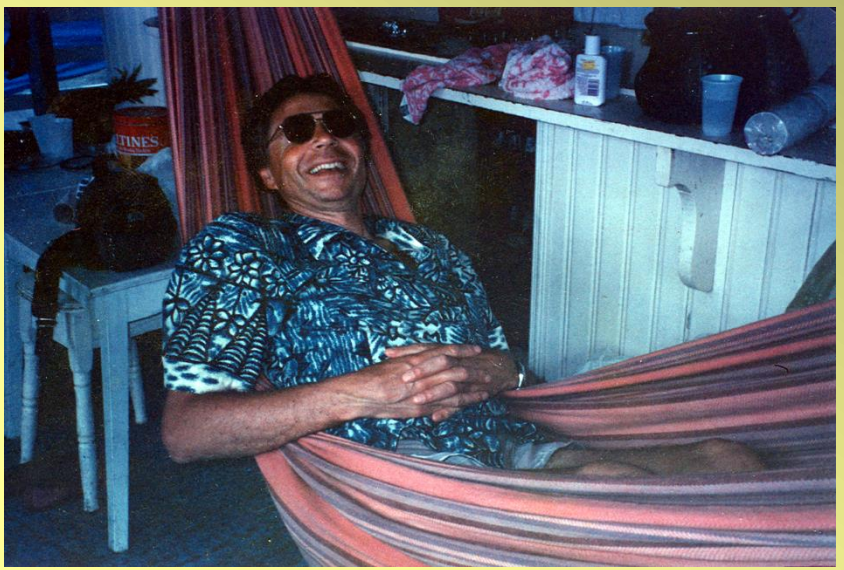
# Well thumbed volume – well before the internet

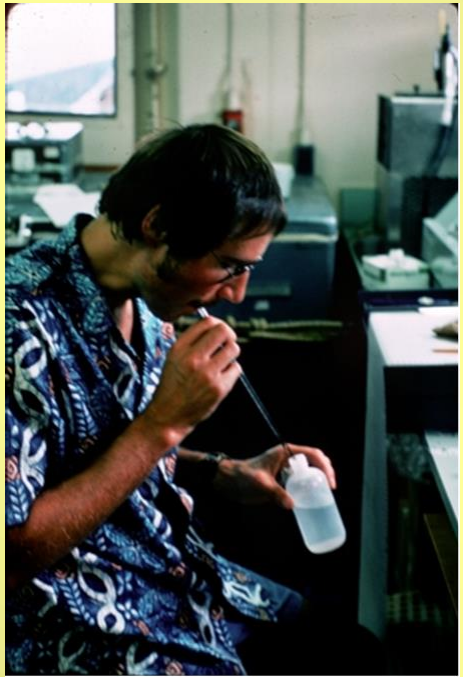



NOT in the Book:

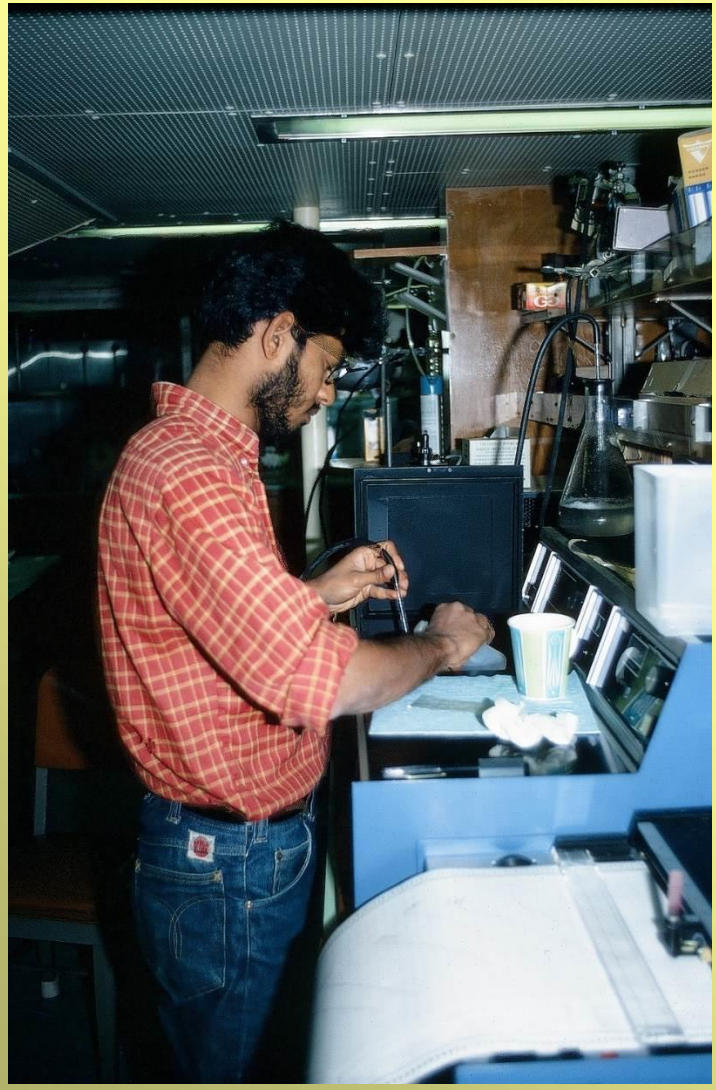
- key flip, whistling on his way home
- phoning at 6 am [bored when alone]
- made my courses go away
- Comprehensive exam in Zoology !!
- predicted the exact results of my thesis before it started
- My actual thesis project created from a turtle paced on my desk
- Used phrase " a whirl-wind entered my lab' in describing me…. and also for EVERY subsequent student in their letter of recommendation.
- Like water off a duck's back!

# In the field; In the lab





# Tom & Tariq & Enzymes



**Lone rider on a Horse – the Way it Was**

*** We don’t know what the answer will be – we just explain**

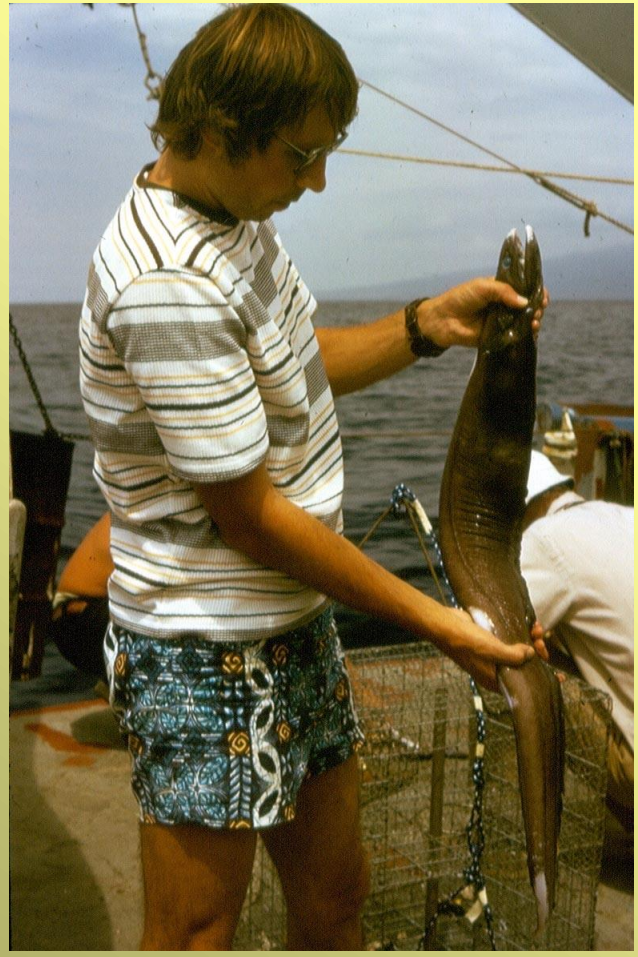
*** When you do transcription factors – don’t just say TA-DA**

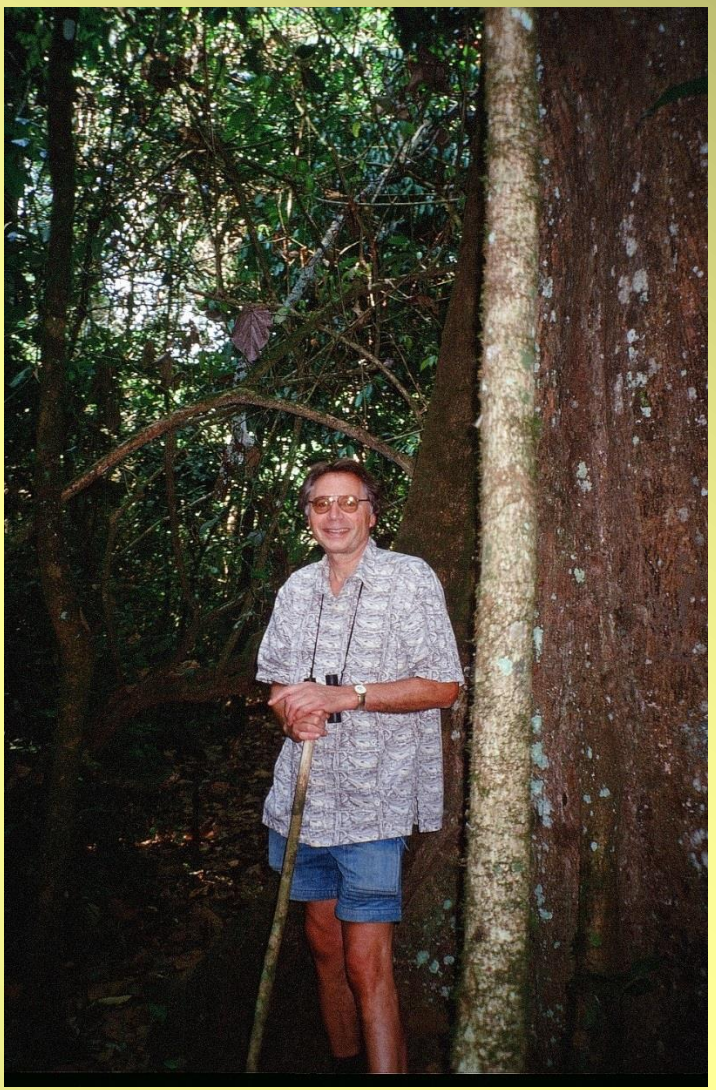
*** New technology will come and change our ideas**

**Our only meeting before I joined Peter's lab.**
**Helga was the gateway for my transfer to Zoology.**

**[I have still never taken a Biology Course of any kind]**

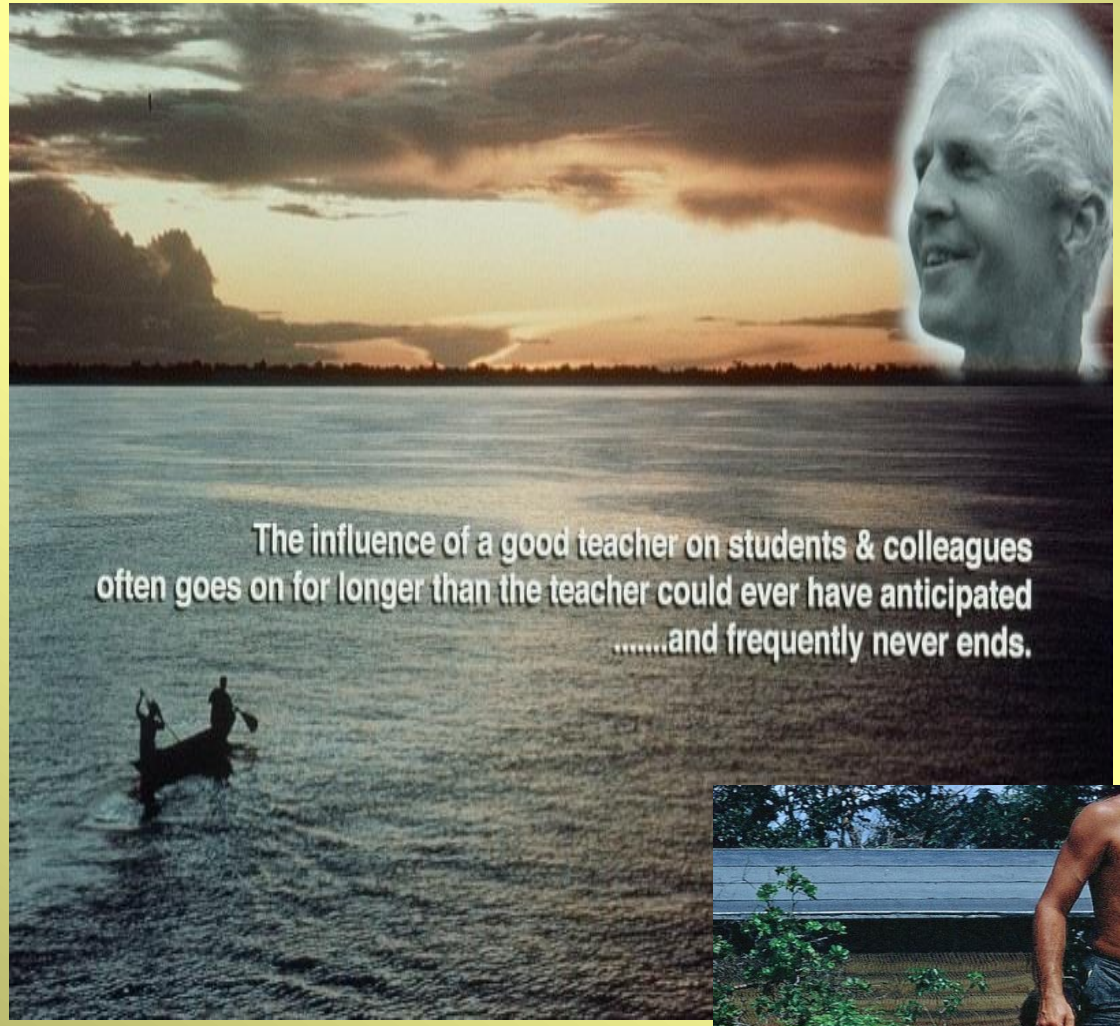
**The World was his oyster.**
**He worked with Janet ON oysters !**



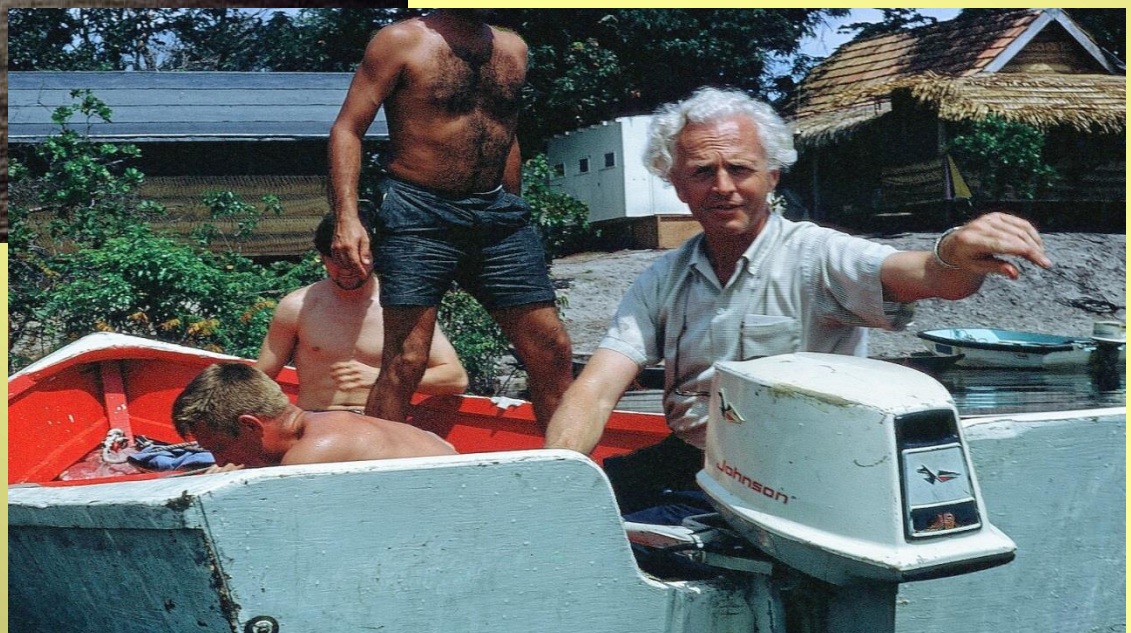


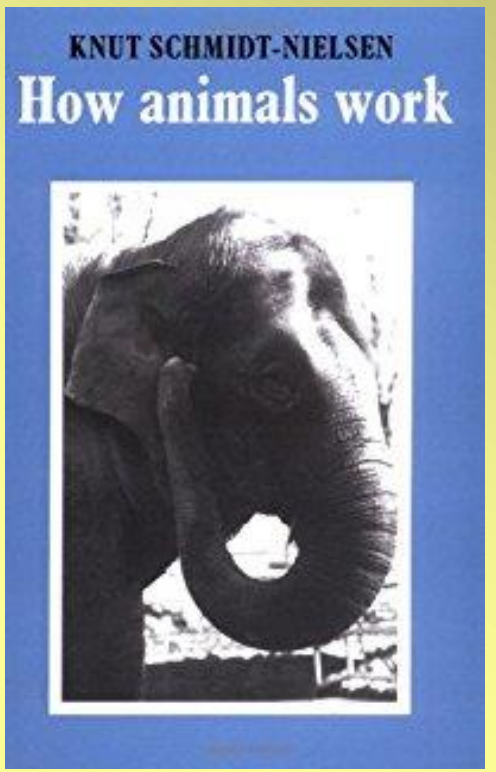
**Picked Jan out of a line-up and stole her**

# Learning in various modes




**Knut Schmidt-Nielsen: A giant that Peter made my faculty colleague**

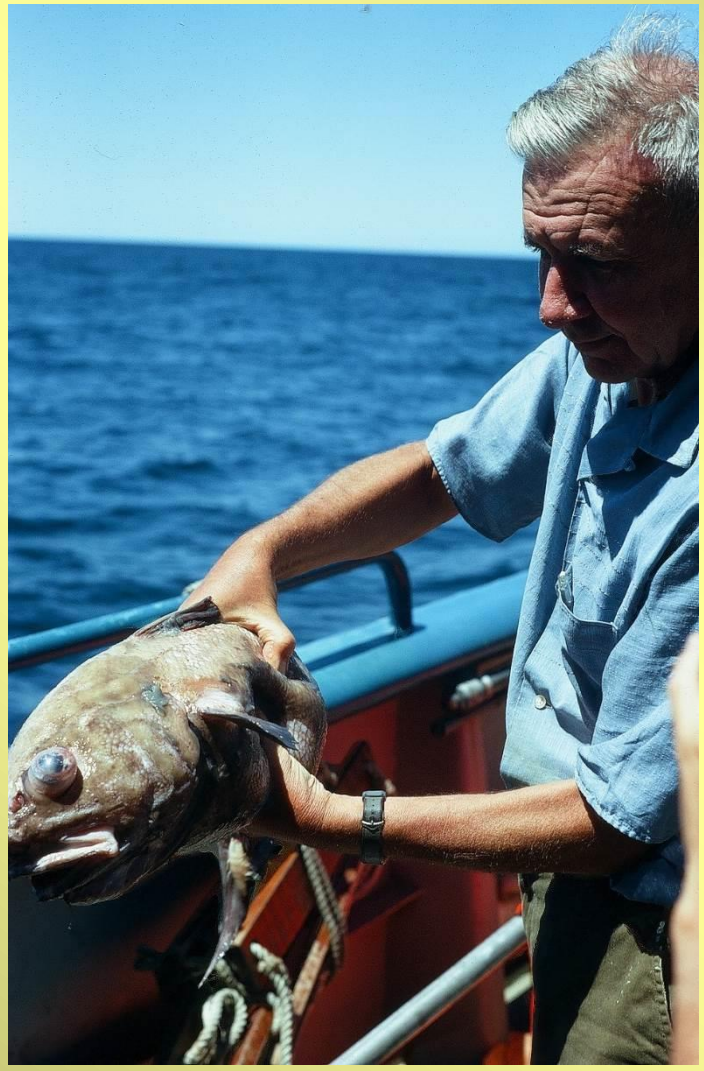



KNUT SCHMIDT-NIELSEN
How animals work

**Froze the first frog as a scientist**

**Kjell Johansen – Viking and Physiologist**

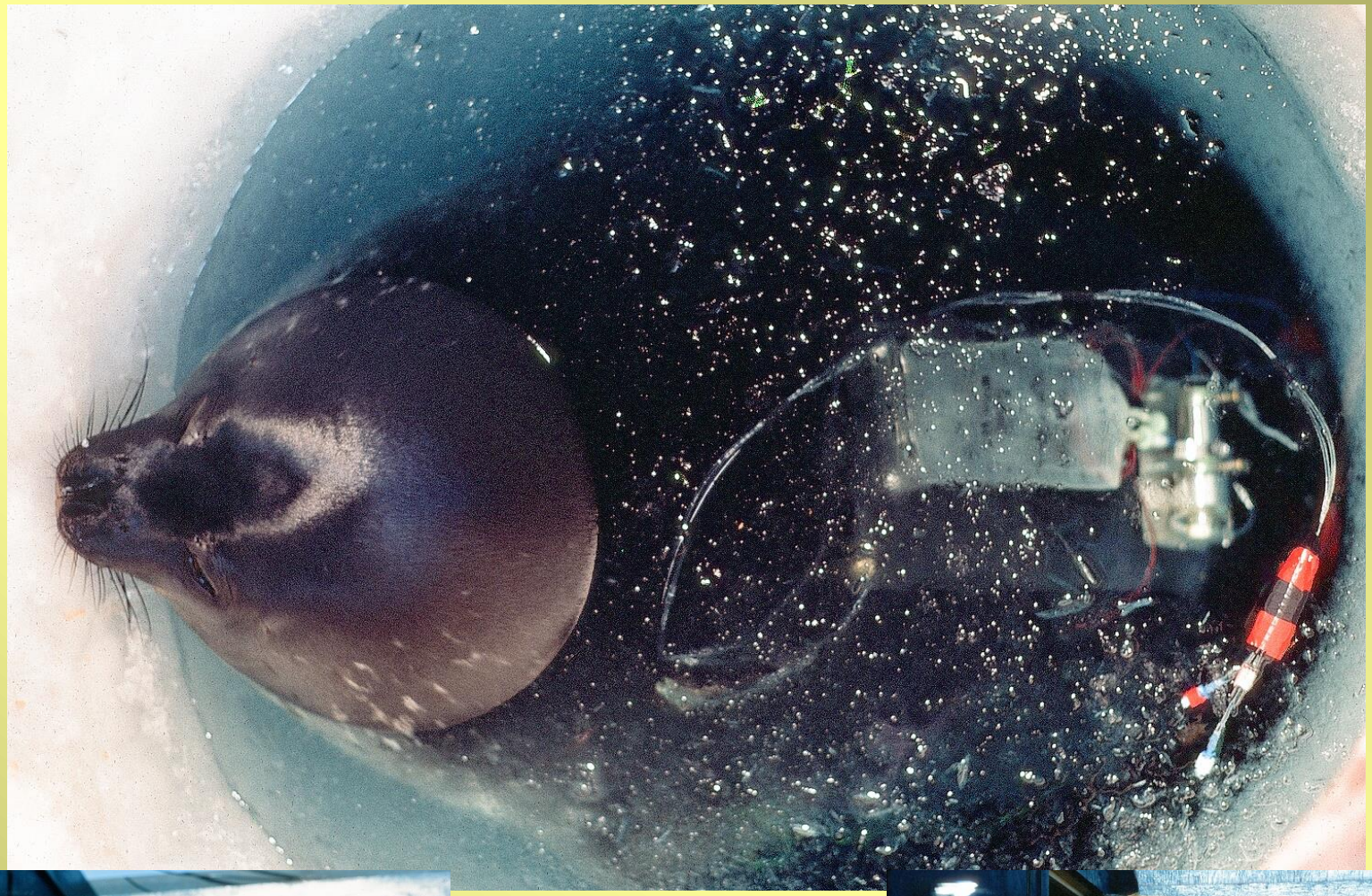
# Ladd Prosser:
# Grand Old Man



**Johnny Baldwin [OG]**
**Fisherman & Scientist**

# On the ice with Warren Zapol

**Fig. 4.** Seal research team (1977) at Byrd Statue of McMurdo Station. Left to right standing: Jesper Qvist, M.D., Sir Graham C. (“Mont”) Liggins, M.D., Ph.D., Peter Hochachka, Ph.D., Thomas R. Wonders. Seated (left to right): Paul Wankowitz, Michael T. Snider, M.D., Ph.D., Warren M. Zapol, M.D., Robert C. “Bob” Schneider, M.D.

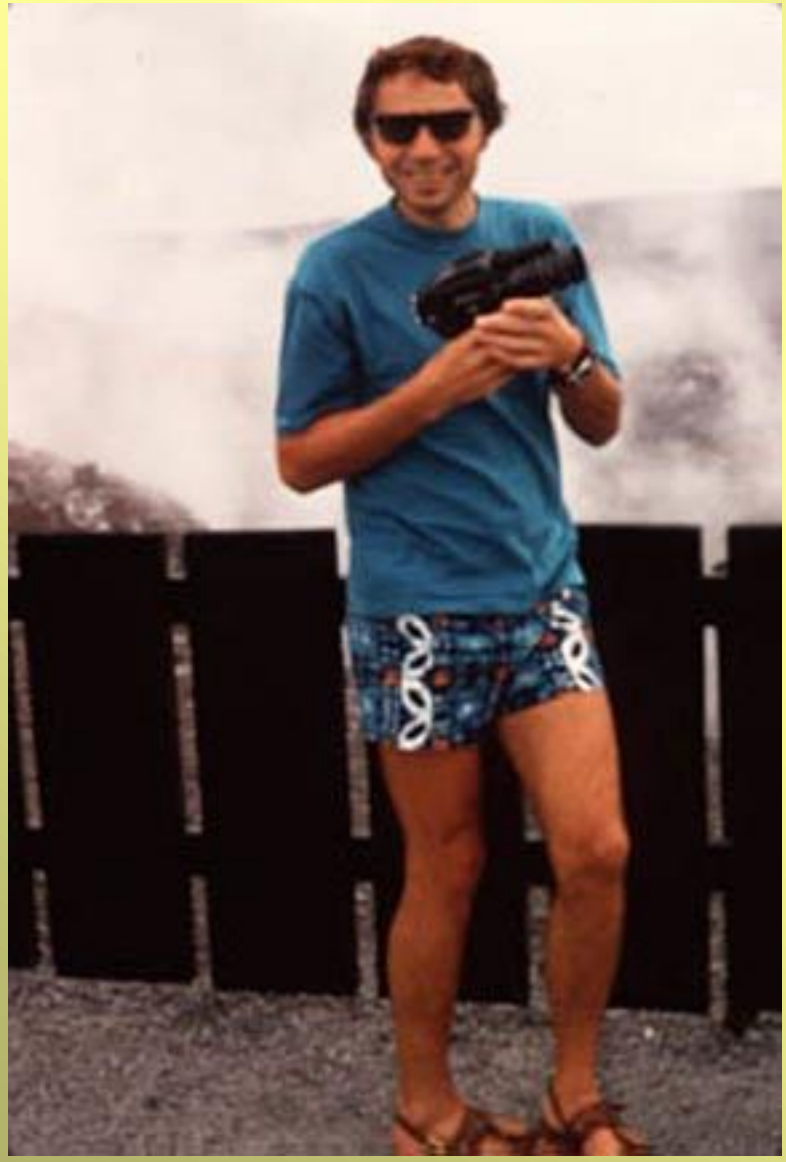


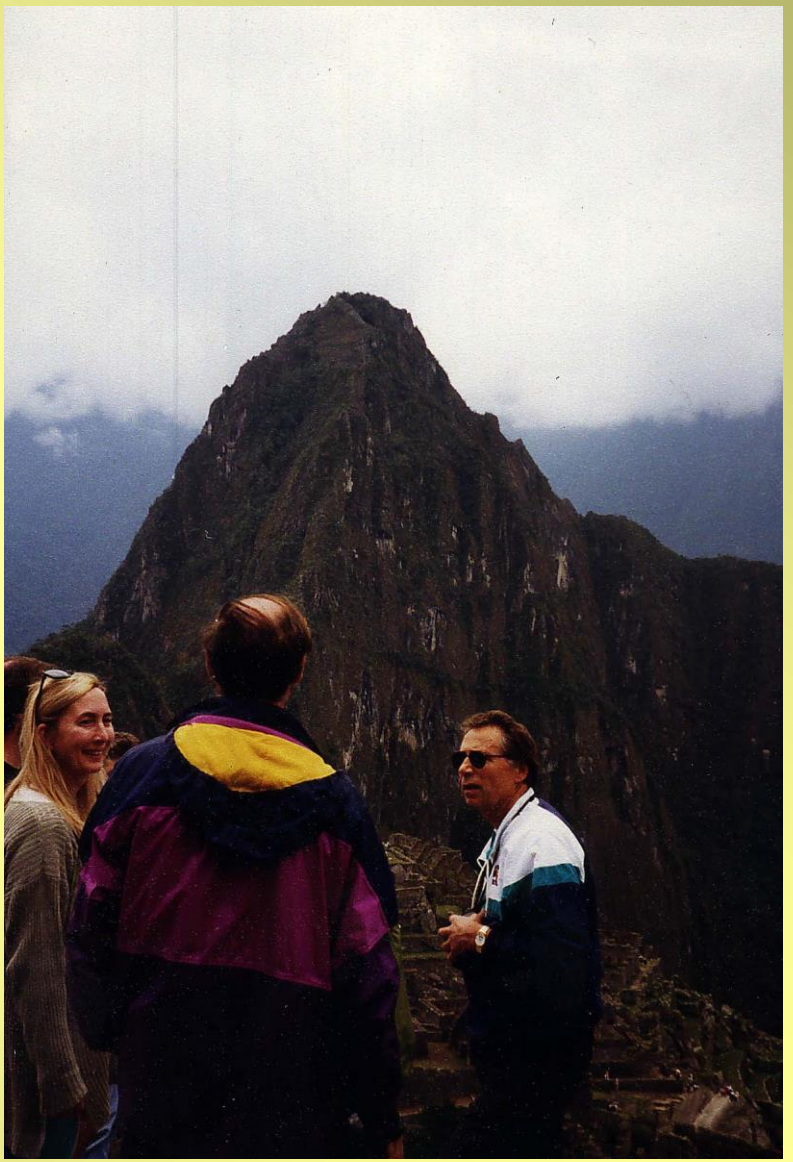

SEAL GENERAL
HOSPITAL


U.S. AIR FORCE
0025
60TH MAW


1344

# Highlanders -- at Sea Level





# Lake Louise Biochemical Adaptation Symposium 1987

Symposium participants, from left to right: J. Ballantyne, T. West, W. Parkhouse, A. Buie, K. Storey, J. Nener, H. Guderley, M. Castellini (at front), C. Moyes (at back), R. Suarez, J.-M. Weber, W. Driedzic, L. Buck, T. Petersen, E. Shoubridge, T. Mustafa, C. Doll, J. Fields, G. Pogson, T. Moon, B. Murphy, P. Hochachka, M. Guppy.

# Lake Louise – the Gathering in the Snow

**Alpha Helix:**
**Home away from home**

**Alpha Helix:**
**Amazon 1976**


**Peter's group in 1992 – Vera Val**

**Peter in Caxambu, Brazilian FASEB 1998 - VeraVal**

**A Group that Peter made uniformly successful.**

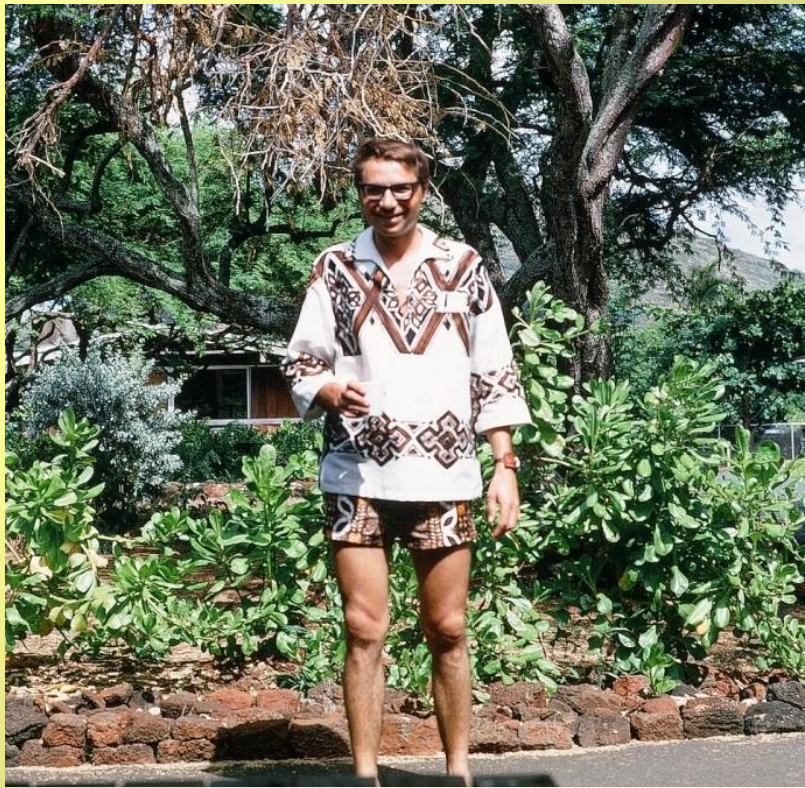
**- he optimized his lab's *opportunities***

**- opportunities presented……outcomes expected**

**- repeated over many decades.**

**Did you have a SoundTrack ?**

**Our time: Rolling Stones, The Who, Fleetwood Mac**



**“They say you die twice. One time when you stop breathing and a second time, a bit later on, when somebody says your name for the last time.” - Banksy**

# Picture Gallery

**Many thanks for photos supplied by:**
**Brenda Hochachka, Tom Moon,**
**Brian Murphy, Dave Jones,**
**Jean-Michel Weber, Mike Guppy**

**Thanks to Jan Storey for photo layout.**

**These pictures and more are available at:**

**CC**


R/V Alpha Helix
Amazon, 1967