Running the Rapids with Norman
From Physical Chemistry to Biology
1958-1962

I came West to Caltech in the fall of 1958. My first love in science was chemistry, and I was eager to explore how far this discipline could take me into biology. Linus Pauling was not taking graduate students and so I began to explore the Kerckhoff Laboratories.

Early on the afternoon of that first day, I came upon a wiry figure in shorts, walking in the courtyard outside Kerckhoff, bouncing a tennis ball and deep in thought. I was startled to see him approach collision with an unseen bench, lurking across his path.   But, no, he saw it at the last moment and lept neatly over the bench. "That's quite different from the professors I have known back East," I thought to myself as I retrieved his tennis ball.

"Hi, I'm Norman Davidson," he said. "I study chemical kinetics with shock tubes. I would like to study the chemistry of DNA. What are you interested in?"

That encounter started an exhilarating four years working with Norman, moving from physical chemistry to biology. The '50s and '60s was a formative stage in the emergence of molecular biology, and Caltech stood in the midst of that dynamic birth process. I shall describe that time in the form of an allegory that I call **Running the Rapids with Norman**.

STATISTICAL MECHANICS

NORMAN DAVIDSON

Professor of Chemistry
California Institute of Technology

McGRAW-HILL BOOK COMPANY, INC.   1962
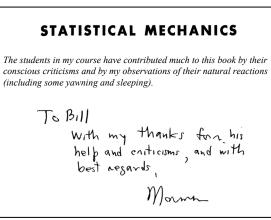*New York   San Francisco   Toronto   London*

Norman was already a highly respected professor of chemistry in 1958. He taught Statistical Mechanics to chemistry and physics graduate students, including me. This effort produced a text for advanced students, published in 1962.

STATISTICAL MECHANICS

Contents

PREFACE

The content of statistical mechanics went all the way from mathematical principles to molecular principles.

Davidson treated us students as colleagues, thanking us for our responses.

STATISTICAL MECHANICS

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The students in my course have contributed much to this book by their conscious criticisms and by my observations of their natural reactions (including some yawning and sleeping).

STATISTICAL MECHANICS

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To Bill
With my thanks for his help and criticisms, and with best regards,

Norman

More amazingly, two elements came forward and were used in my thesis: Order-Disorder Phenomenon, and the Theory of Solutions of Electrolytes.

In the allegory I shall give today, three other concepts will arise metaphorically: the grand canonical ensemble, free energy, and work.

STATISTICAL MECHANICS

Contents

PREFACE

Here is the doctoral thesis that I presented to the Chemistry faculty three years later. It continued his inorganic and physical chemistry, now with macromolecules.

THE HELIX-COIL TRANSITION IN DNA: EFFECTS OF THE INTERACTIONS WITH SMALL IONS AND OF THE COMPOSITION OF DNA.

Thesis by
William Franklin Dove

In Partial Fulfillment of the Requirements
For the Degree of
Doctor of Philosophy
Chemistry Division
California Institute of Technology
September 1961

But it was a major stylistic transition in Norman's career.

He was very much amused when he came upon a sentence within Appendix II of my thesis describing the culture media that we used to grow pneumococcus for DNA transformation. Five ml of medium used 0.1 ml of sterile rabbit blood. Norman insisted on making a footnote to explain that, in fact, it's the blood that's sterile, not the rabbit.

APPENDIX II.   Media used in tranformation.

P medium: For culture of strains and for precultures in experiments.
     Difco neopeptone   5 g.
     NaCl (Reagent)   4.2 g.
Dissolve in 500 ml distilled water, autoclave at 120° for 20 minutes. For use, to each 100 ml add 0.1 ml 1 F NaOH, 0.125 ml 10% glucose, and 8 ml sterile charcoal-absorbed yeast extract (vide infra). For culture of strains, use 5 ml in tubes with 0.1 ml **sterile rabbit blood***, incubate 1:20 inoculum about 2 h.

*The blood is sterile, not the rabbit.

So we saw in four years time the transition from Norman as an experimental physical chemist, publishing papers like these,

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From Physical Chemistry to Biology
1958-1962

Before:

McConnell, H. and Davidson, N. (1950) Optical interaction between the chloro-complexes of copper(I) and copper(II) in solutions of unit ionic strength. *J. Am. Chem. Soc.* **72**, 3168 - 3173.

Britton, D., Davidson, N., and Schott, G. (1954) Shock waves in chemical kinetics: The rate of dissociation of molecular iodine. *Disc. Faraday Soc.* **17**, 58 - 68.

Bunker, D. L. and Davidson, N. (1958). A further study of the flash photolysis of iodine. *J. Am. Chem. Soc.* **80**, 5085 - 5090.

ND: *National Academy of Sciences 1960*

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to a molecular geneticist.

From Physical Chemistry to Biology
1958-1962

After:

Dove, W. F., Wallace, F. A., and Davidson, N. (1959) Spectrophotometric study of the protonation of undenatured DNA. *Biochem. Biophys. Res. Comm*. **1**, 312 - 317.

Dove, W. F. and Davidson, N. (1962) The thermal inactivation of transforming activity at low ionic strength. *J. Mol. Biol*. **5**, 479 - 486.

Yamane, T. and Davidson, N. (1962) On the complexing of deoxyribonucleic acid by silver(I). *Biochim. Biophys. Acta* **55**, 609 - 621.

I have been describing some of the science going on in Norman's laboratory between the '50s and the '60s. Let's return to the allegory I have chosen – **Running the Rapids with Norman.**

Keep your feet down!

A few years ago, my wife, Alexandra, and I went rafting on the Colorado and one important message that we learned from our guides was to keep our feet down. Not only in the raft, but also if by chance you are thrown out of the raft as it hits the backwave at the bottom of the rapids: keep your feet headed downstream. Norman Davidson has been able to keep his feet down and been able to emerge successfully from a series of major changes of his science. I see three sources of Norman's equilibrium.
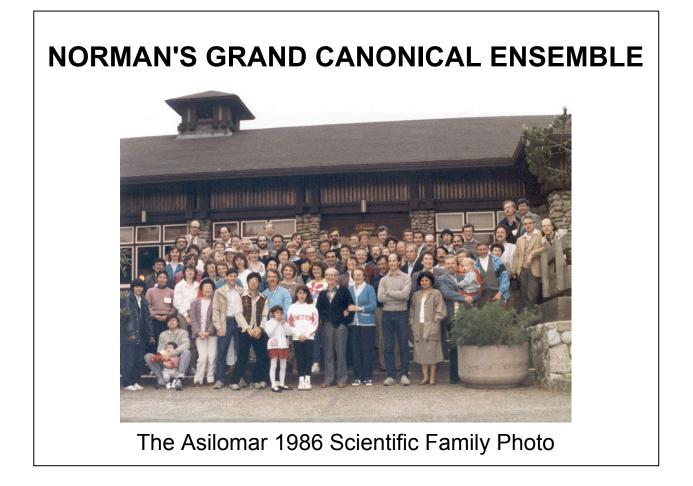
One is Norman's grand canonical ensemble, his way of relating constructively to colleagues junior and senior. The second is his quality of free energy. The third is his respect for hard work.

NORMAN'S GRAND CANONICAL ENSEMBLE

FREE ENERGY

WORK

NORMAN'S GRAND CANONICAL ENSEMBLE

Norman and Annemarie Davidson

Terry
Jeff
Lauren
Brian

Norman's grand canonical ensemble begins with his family, Annemarie, Terry, Jeff, Lauren, Brian and now grandchildren. After we say hello, most of my conversations with Norman continue with "How's your family?" While I was a bachelor doctoral student in Norman's lab, I joined members of his family hiking or skiing.

NORMAN'S GRAND CANONICAL ENSEMBLE

The Asilomar 1986 Scientific Family Photo

Norman's scientific family assembled in force on the occasion of his 70th birthday in Asilomar.

NORMAN'S GRAND CANONICAL ENSEMBLE

Norman and his fossilized school of fish, 1986

Enclosed is a photo of the truly beautiful present you all gave to Annemarie and me. It is on permanent display in our living room. It is beautiful and we really appreciate it.

Norman

As a symbolic gift, we presented him with a sheet of sedimentary rock in which a school of fish had been caught and fossilized. Norman greatly appreciated that symbolism. We who belong to Norman's school of investigators, however, insist that we are not fossilized.

The second equilibrating quality is that of Free Energy. This quality is generated from three different components.

One is that of courage. More than once, while discussing the feasibility of an experiment, Norman quoted one of his favorite sayings from Shakespeare, "Faint heart ne'er won fair lady". Emboldened, we would dare to explore the boundaries of feasibility. Norman attributed this kind of courage to Caltech.
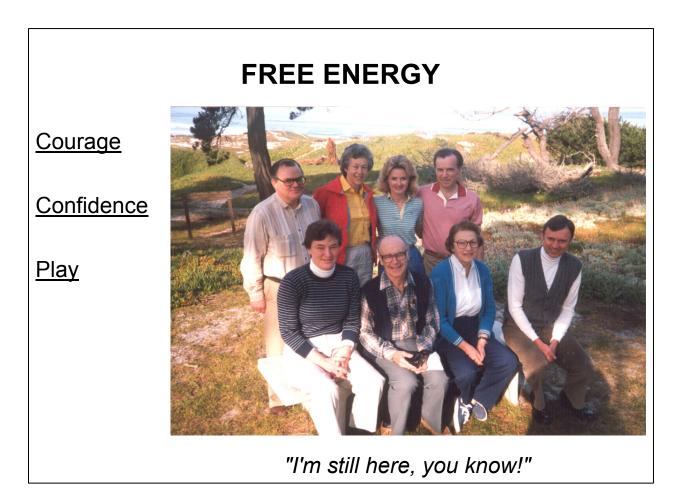

FREE ENERGY

Courage

"Faint heart ne'er won fair lady"

FREE ENERGY

<u>Courage</u>

"Faint heart ne'er won fair lady"

"… Caltech is an environment that understands and appreciates interdisciplinary research and science.

… Even people who don't know anything about it appreciate people moving into new and exciting areas."

Norman Davidson
Caltech Oral History, 1987

In an oral history he pointed out that Caltech is an environment that understands and appreciates inter-disciplinary research and science, that even people who don't know anything about it appreciate people moving into new and exciting areas.

FREE ENERGY

<u>Courage</u>

<u>Confidence</u> (not arrogance)

"You must be willing to be just plain stupid!"

Norman Davidson to Bill Dove, 1960

A second component of his Free Energy is that of confidence. Norman is one of the least arrogant people I have ever known. But his inner confidence was expressed by saying from time to time, "You must be willing to be just plain stupid".

FREE ENERGY

<u>Courage</u>

<u>Confidence</u>

<u>Play</u>

"I'm still here, you know!"

The third component of his Free Energy is that of play. As you might expect, we graduate students, Bob Stewart (upper, left), Dan Wulff (upper, right), and myself, would often repeat some of Norman's sayings after he had left the lab, imitating him. One day while we were studying in our lab he came in, went to the very back of the lab and began fumbling around, apparently trying to fix the dormant shock tube apparatus. We eventually forgot that he was still back there rummaging around and resumed our habit of imitating some of his sayings. From the back of the lab came a call: "I'm still here you know".
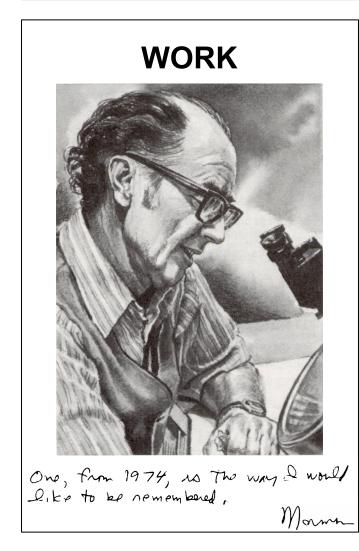
I have shared with you how Norman has landed on his feet by depending upon his three graces:

- his ensemble of family and colleagues
- his free energy; and
- his work.

And the greatest of these is **work.**

WORK

"… He was peaceful and happy as long as he could work."

Norman Davidson *re* J.J. Weigle, 1901-1968

Several decades ago, in this very Athenaeum, Norman gave a tribute to Jean Weigle, his phage mentor and mine. Jean had died early of a heart condition. Davidson's final word was this: "Jean was peaceful and happy as long as he could work". In Norman, we are looking at a person who was actively involved in his work almost to age 86!

WORK

One, from 1974, is the way I would like to be remembered,

Norman

All of us are sad to be losing Norman Davidson, such a force in our lives. But Norman prepared us for this inevitability with characteristic grace.

"This is the way I would like to be remembered," he said decades ago as he sent me a photograph of him working at his electron microscope.

Norman's work and spirit has made an indelible imprint on each of us.