Nano-Bio-Info-Cogno Convergence
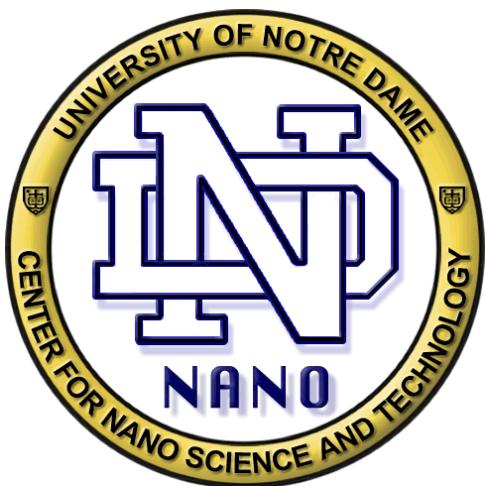
Wolfgang Porod
*Center for Nano Science
and Technology
University of Notre Dame*
http://www.nd.edu/~ndnano

ISCAS Forum ● Vancouver ● 23 May 2004

# NBIC Convergence:
Attributes and Drivers

Nano: **small size, light weight, low power**

Bio: **nature-inspired, engineer like nature**

Info: **computation, communication**

Cogno: **human-centered**
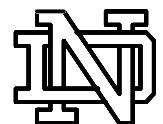
NBIC Project:

MURI Project

Notre Dame

Berkeley, Harvard

Int'l: Budapest, Seville

Collaboration
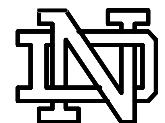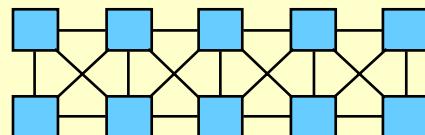
**Analogical and Neural Computing Laboratory
MTA-SzTAKI, Budapest, Hungary**
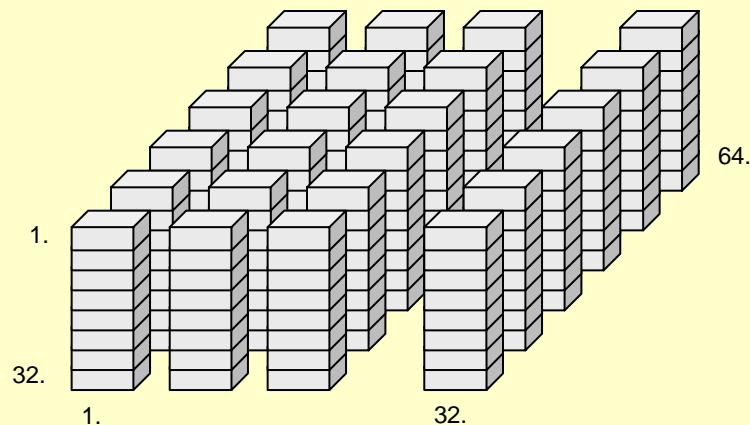
65536 (32*32*64) Power PC

128 x 128 processor
with optical input

*IBM Cellular
Supercomputer 2002*

Computing Power ~ 12 * 10^{12}
(**TeraFLOPS**)

*An analog-and-logic CNN
supercomputer*

Computing Power ~ 12 * 10^{12}
(**TeraOPS**) equivalent

A = 65536 x 1.06 cm^2 = 6.9468 m^2

P = 491 kW

A = 1.4 cm^2

P = 4.5 W

Vision 2003, Stuttgart

Bi-i

AnaLogic Computers

Bi-i, The highest speed camera-computer of the world;
Image processing with 20, 000 frame per second

University of Notre Dame   *Center for Nano Science and Technology*
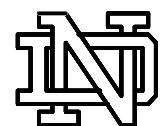
Nanotechnology for CMOS-compatible multi-spectral, dynamically-integrated sensors

- **Multispectral Sensors**
  - Lithographically-defined Nanoantennas
  - Electrostatically-tunable MEMS Fabry-Perot
- **Nanoantenna + Metal-Oxide-Metal Diode**
 - Design and Layout
  - Initial Modeling
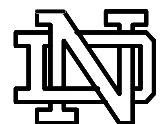
MEMS Electrostatic-Tunable Fabry-Perot Interferometer Spectrophotometer/Photodetector Combination

Cross-Section Line
20 µm
TOP VIEW (metallization not shown)

Polysilicon
Silicon Nitride
Aluminum Contact
Air Gap
Aluminum Contact
Polysilicon
Silicon Dioxide
n+ Layer
n-Type Epitaxial Layer
p-Type Substrate
CROSS-SECTIONAL VIEW
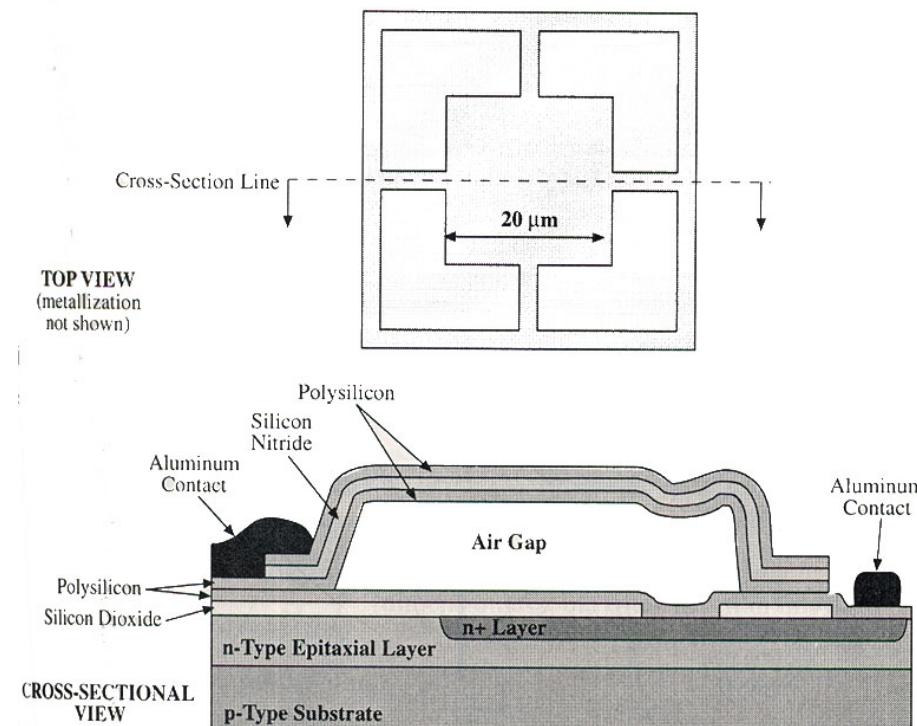
- Proposed by K. Aratani et al. in 1994
- Apply surface micromachining techniques in process, compatible with standard CMOS process.
- Photodiode is integrated, which can be used as the detector of CCD
- Use electrostatic force to adjust the air gap
- Designed for an incident wavelength of 780 nm

K. Aratani etc., Sensors and Actuators A, 43(1994) 17-23
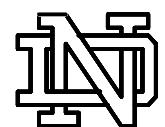
Lithographically-Defined Nanoantennas
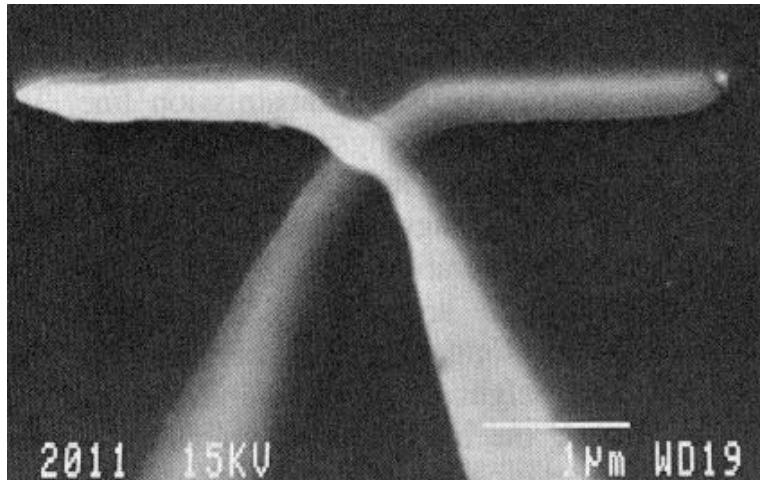
Dipole antenna with MOM diode, which functions at THz frequencies

I. Wilke, W. Herrmann, F. K. Kneubuhl, "Integrated Nanostrip Dipole Antennas for Coherent 30 THz Infrared Radiation," *Appl. Phys. B* **58**(2), pp. 87-95 (1994).
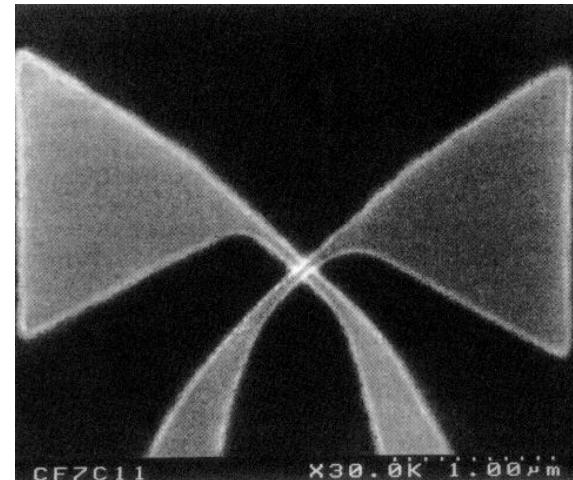
Bowtie antenna with MOM diode, which operates in the visible

C. Fumeaux, J. Alda, and G. D. Boreman, "Lithographic Antennas at Visible Frequencies," *Optics Lett.* **24**, 1629-1631 (1999).

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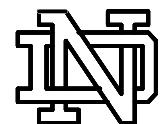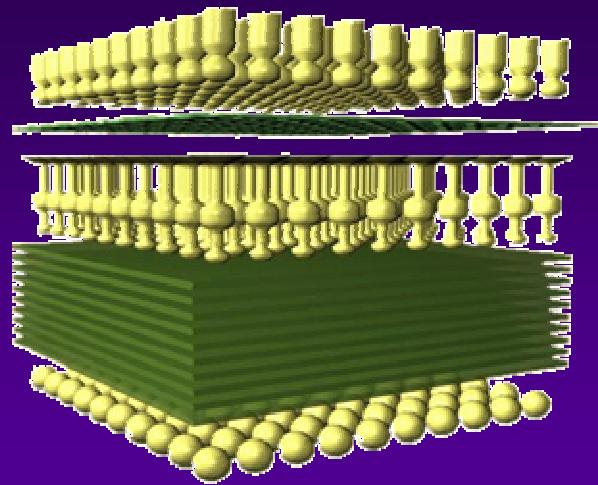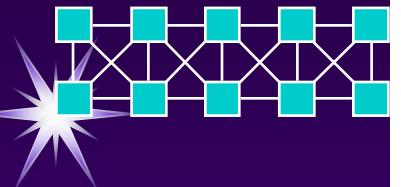
The mammalian retinal visual language in CNN

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Tamas Roska

Analogical and

Neural Computing Laboratory

Hungarian Academy of Sciences

**Budapest, H-1117, Hungary**
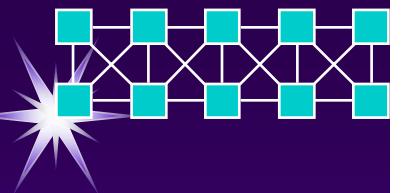
Computational structure

Connected pairs of diffusion layers
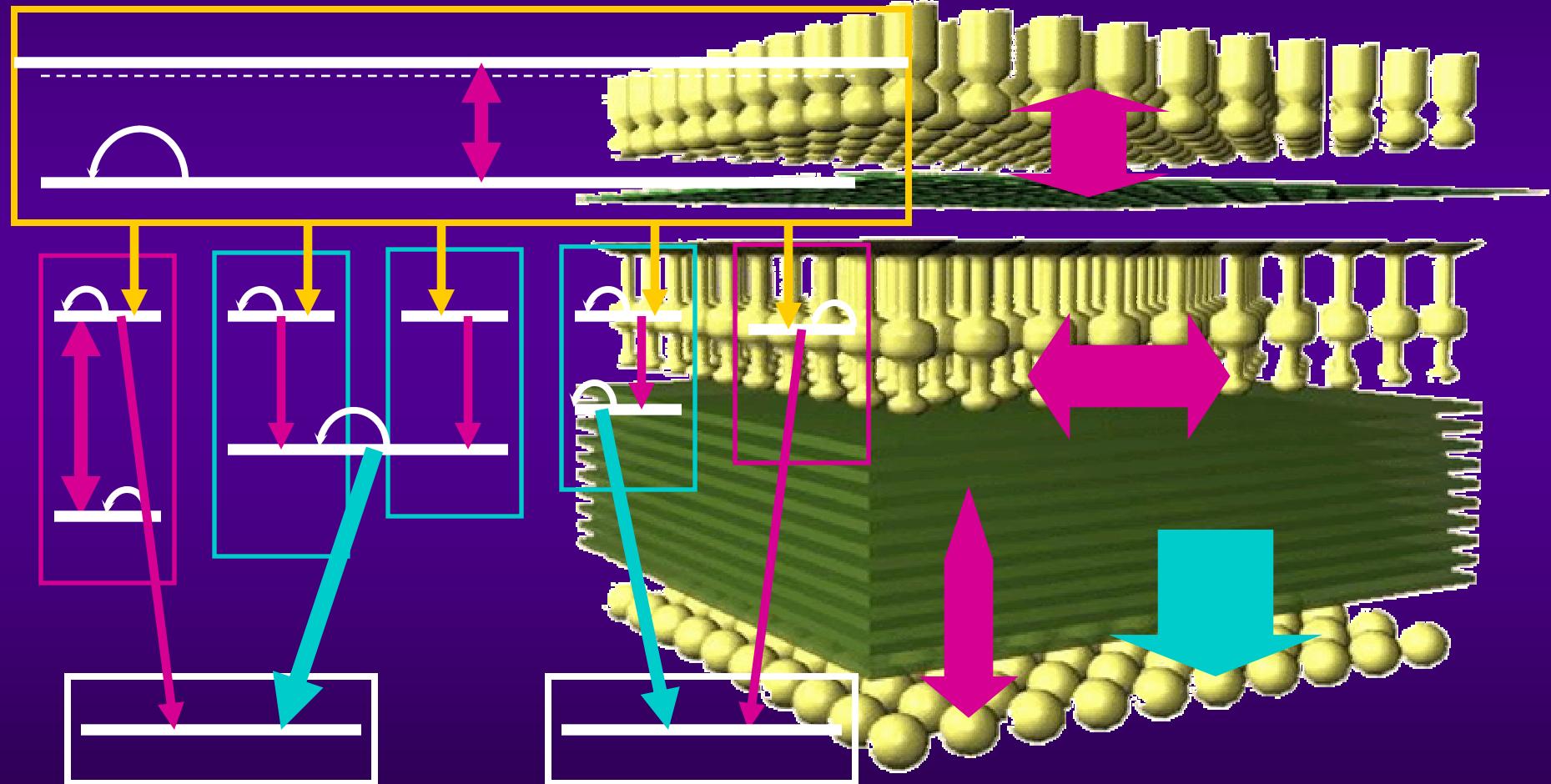
**Functional complexity**

IN: Video
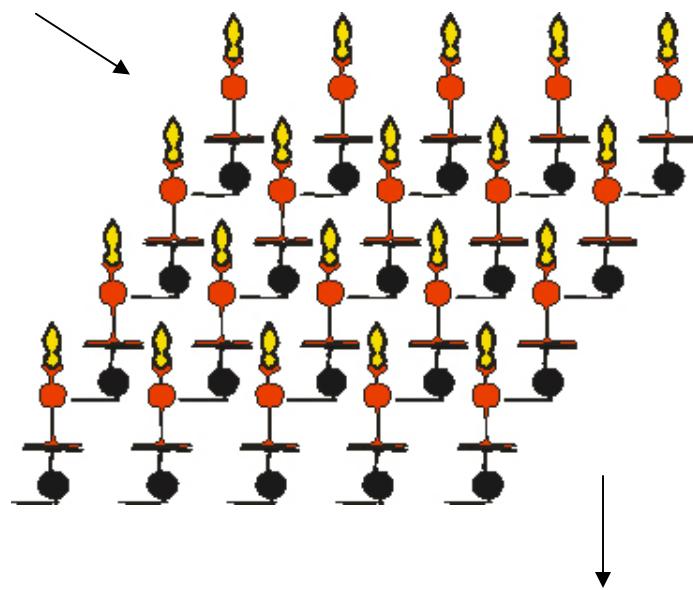
Botond Roska
Harvard

Retina: Image flow transformation

OUT: Multiple Space-time Neural representations

1   2   3   4   5   6   7   8   9   10

Left eye   Right eye

Pupillary muscle

Ciliary ganglion

Retinal ganglion cell subtypes

EWN

OPN
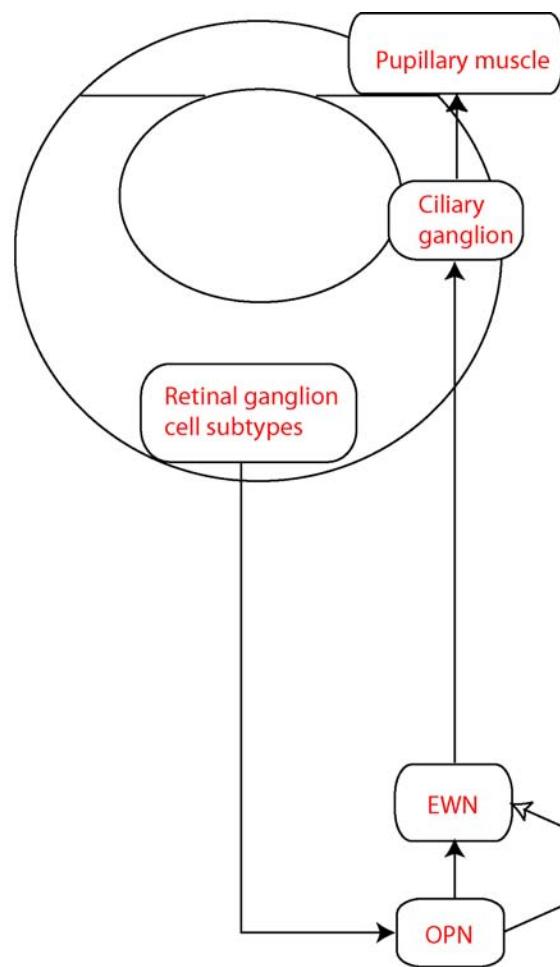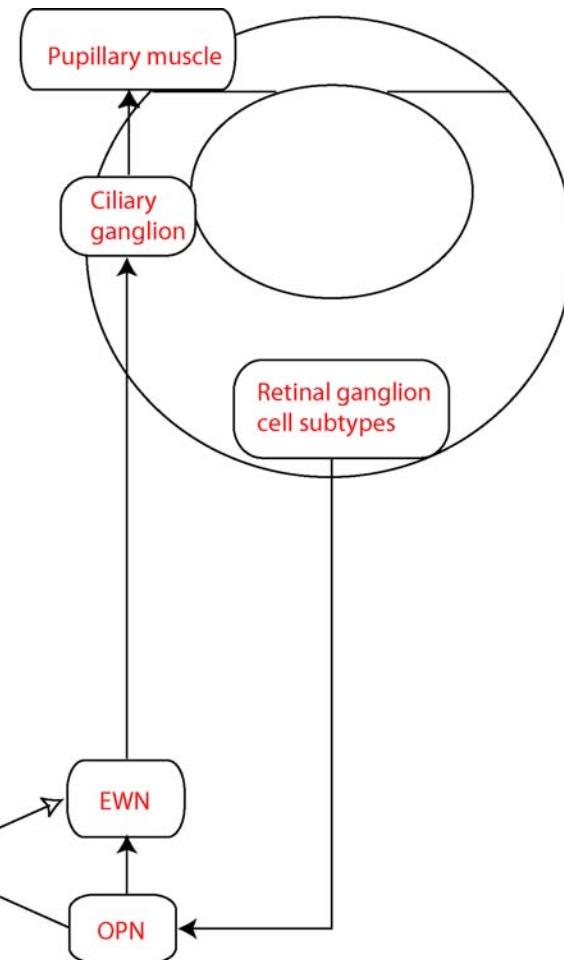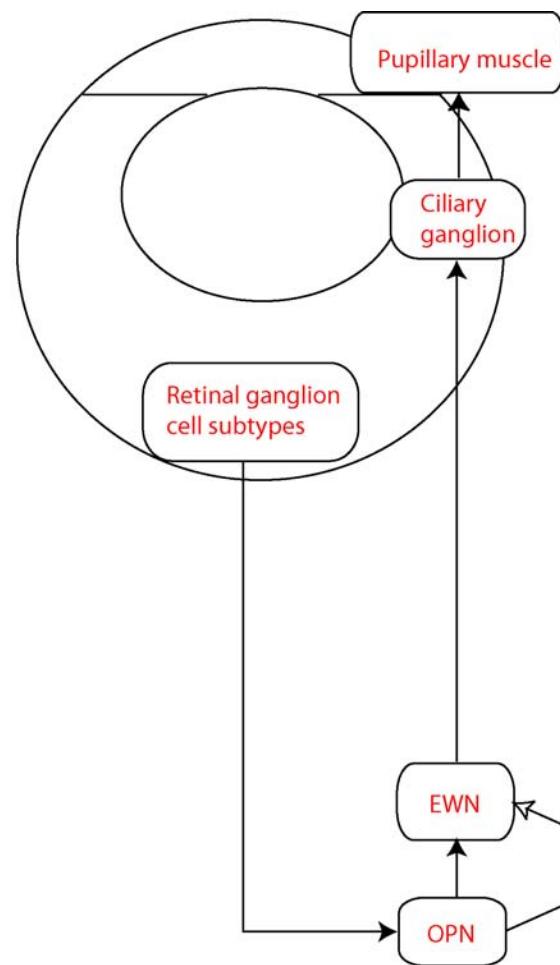
**Botond Roska,** *Harvard*
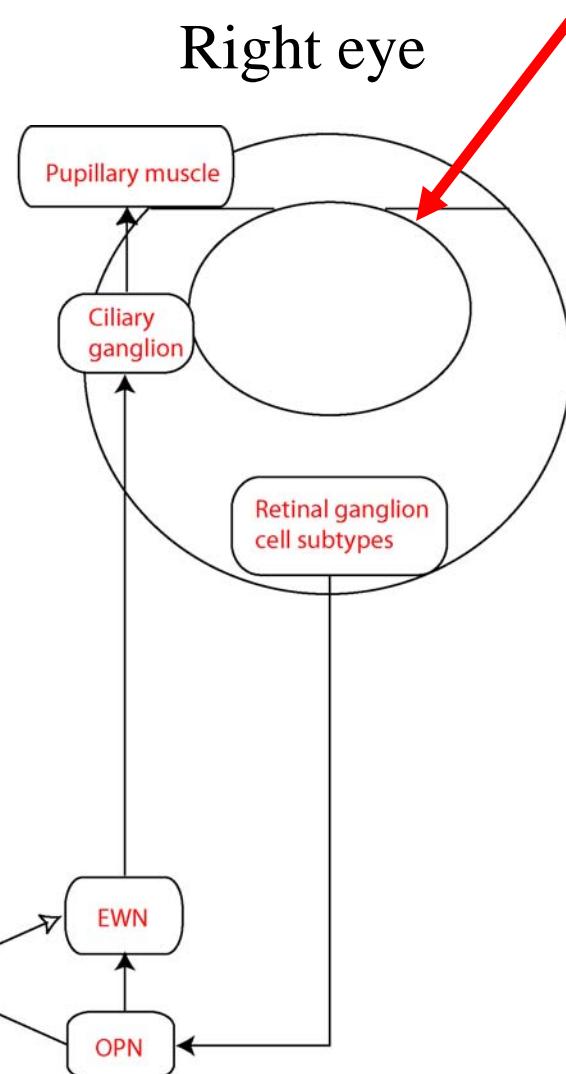
Botond Roska, *Harvard*
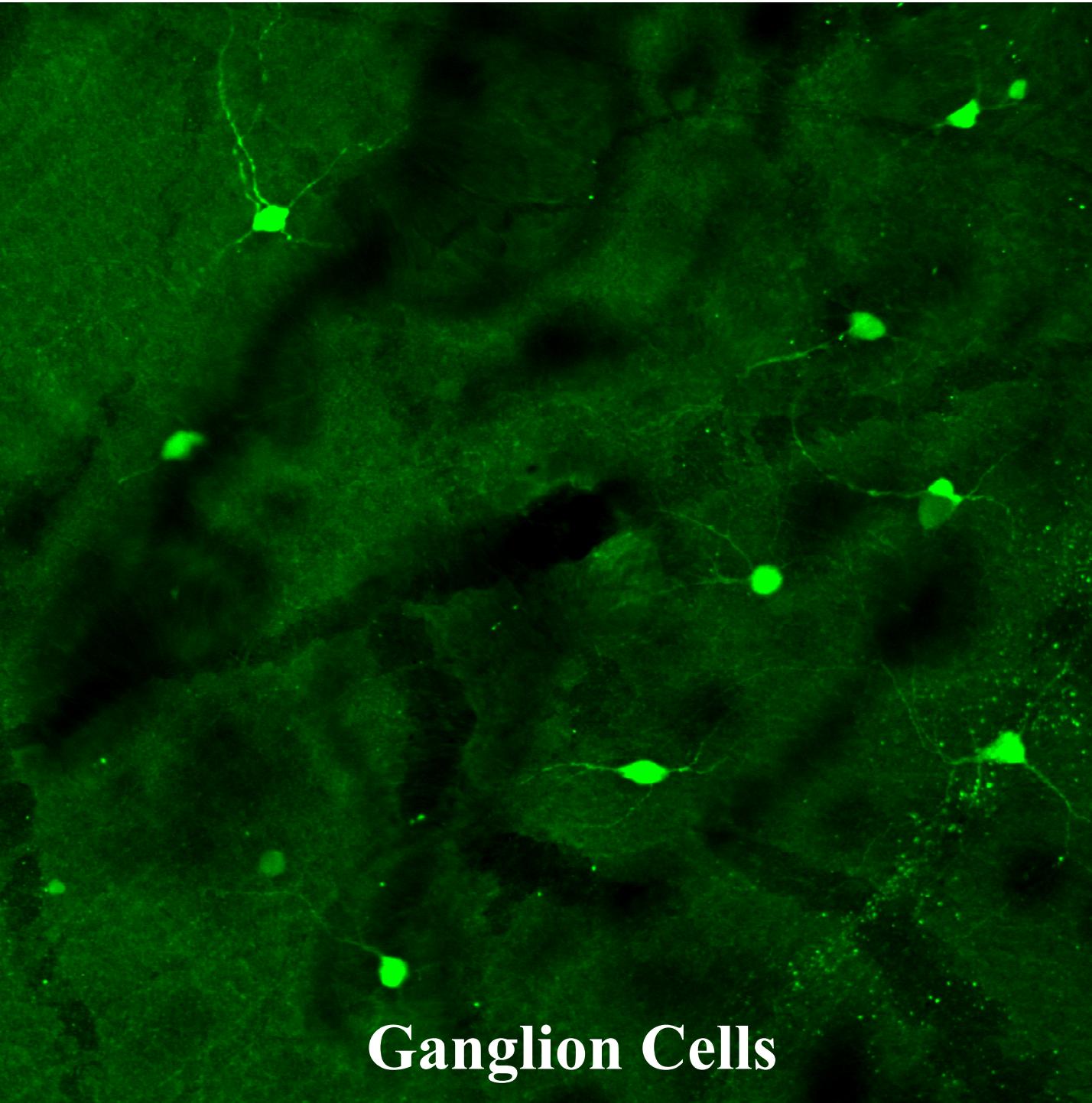
Ganglion Cells
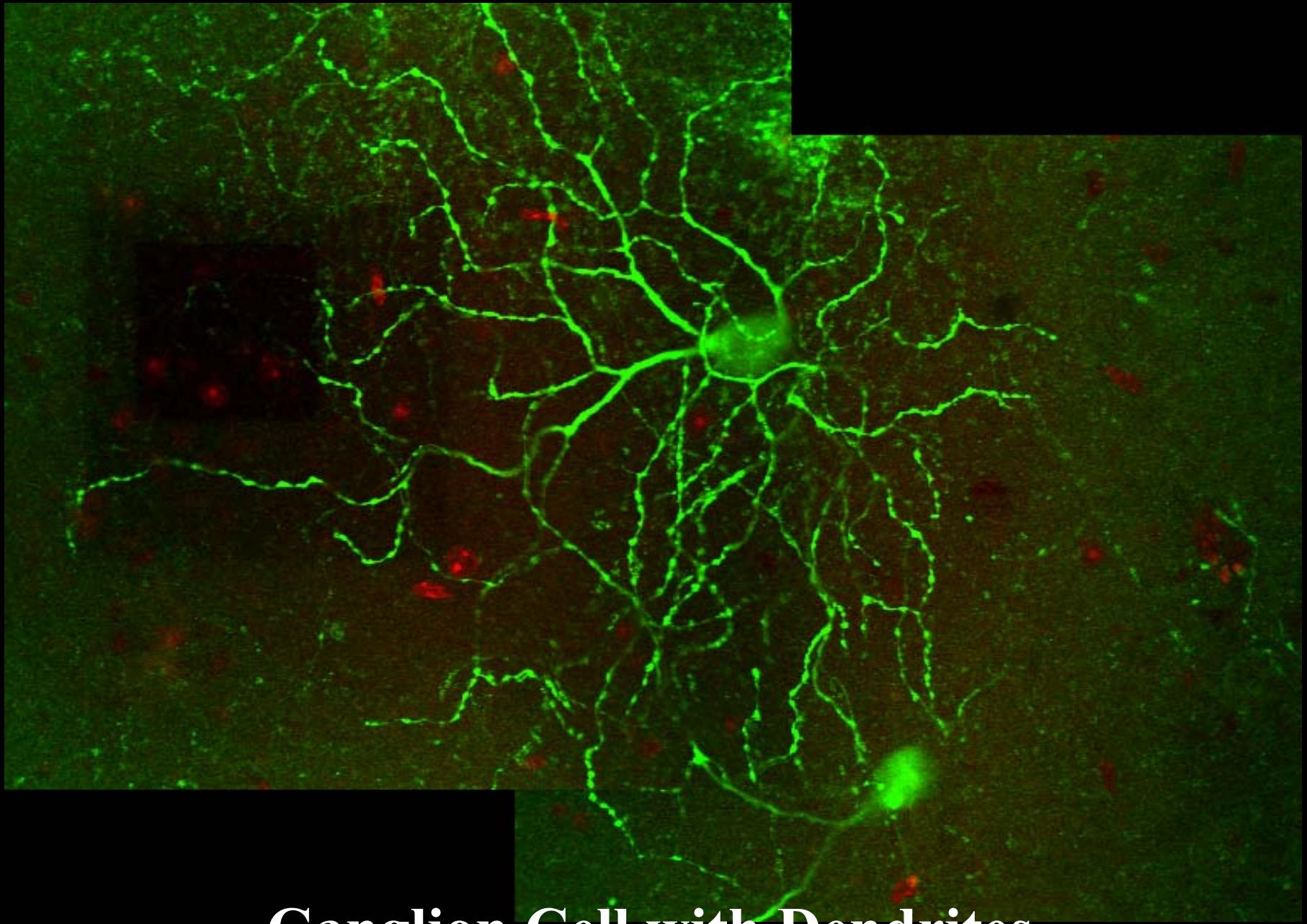
Ganglion Cell with Dendrites
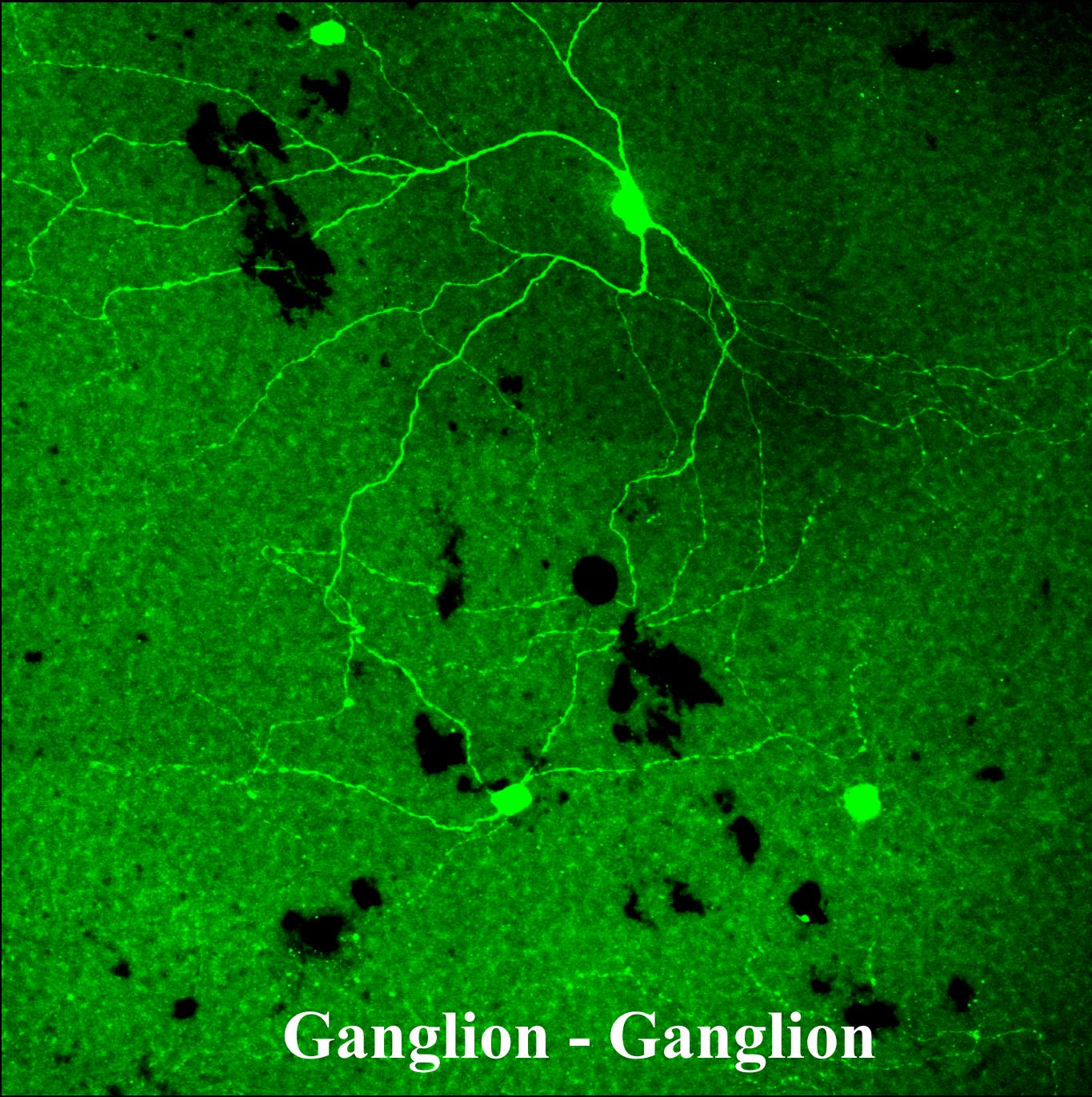
Ganglion - Ganglion

Acknowledge Collaborators

- Leon Chua, NOEL, UC Berkeley
- Frank Werblin, VRL, UC Berkeley
- Botond Roska, Harvard
- Gary Bernstein, Patrick Fay, Yih-Fang Huang, ND

- Tamas Roska and Arpad Csurgay, Budapest
- Angel Rodriguez-Vazquez, Seville