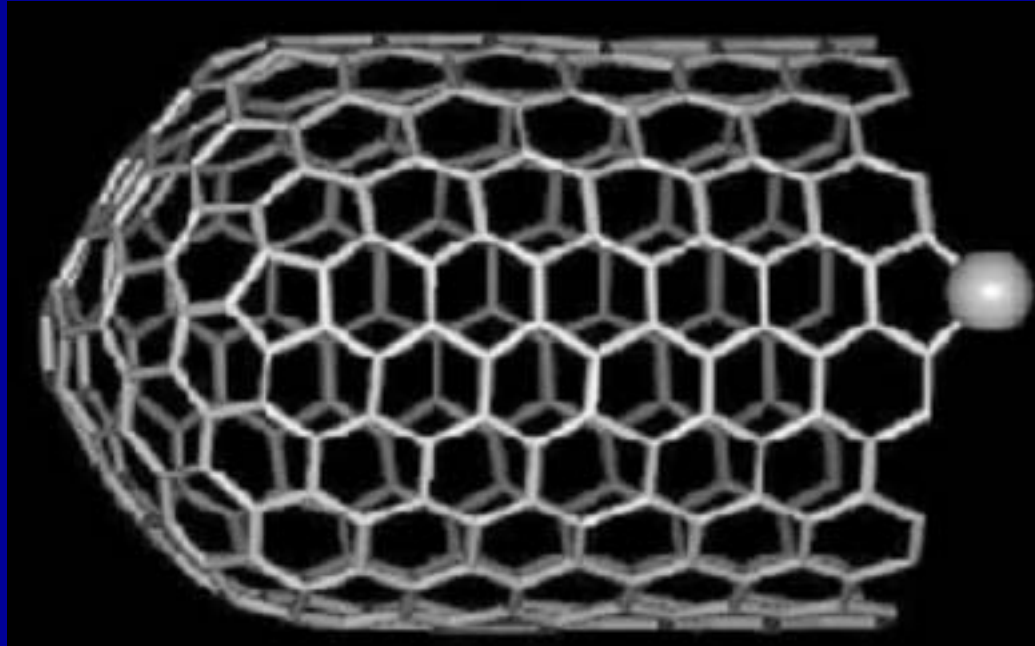




Biomolecular Doping of Carbon Nanotubes

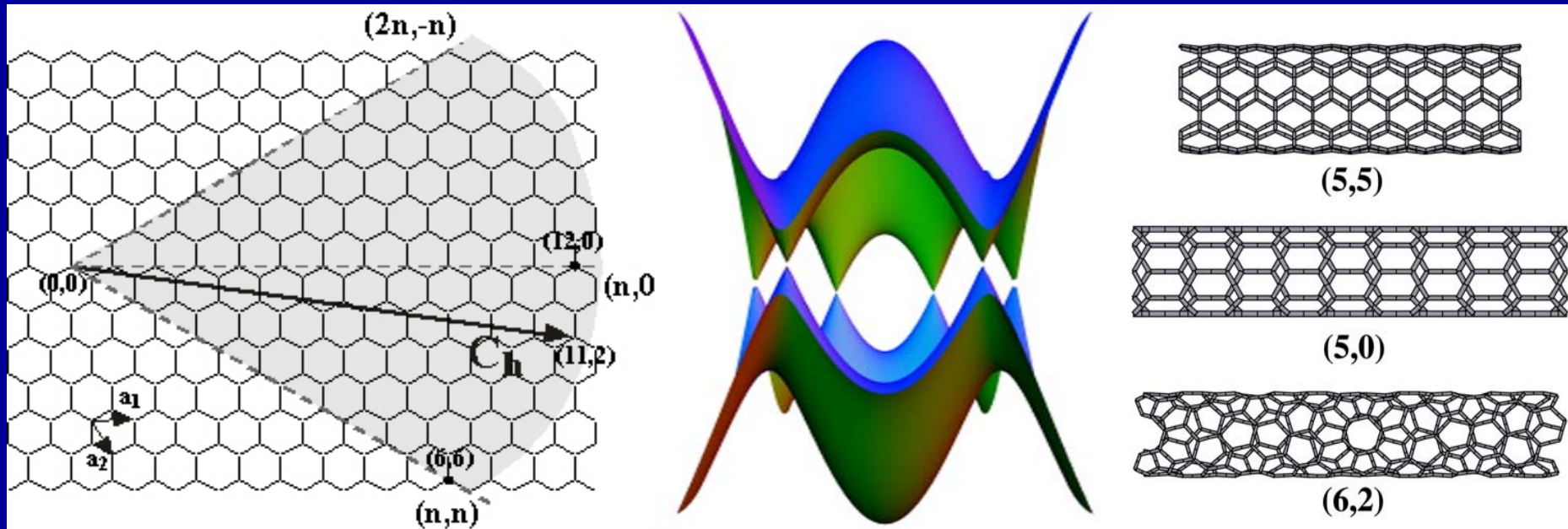


Enrique Rojas, Mike Stern, Scott Paulson,
Mary Dratman and Charlie Johnson



Overview:

Nanotube Geometry Determines Electronic Properties: Metals or Semiconductors



The coordinates (n_1, n_2) specify unique structure

2D Band-Gap structure for Graphene

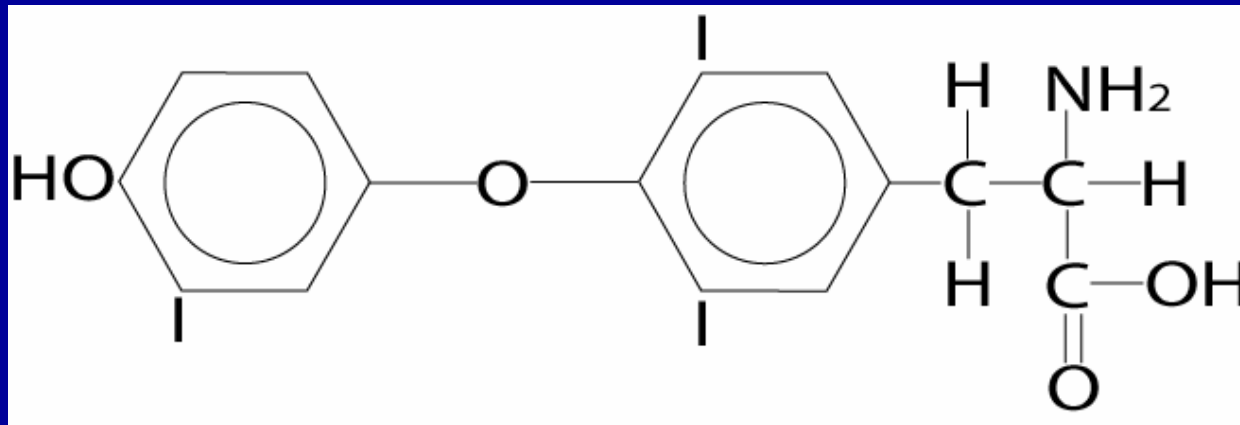
1. Zigzag
2. Armchair
3. Chiral

Metals Satisfy:

$$2n_1 + n_2 = 3p$$

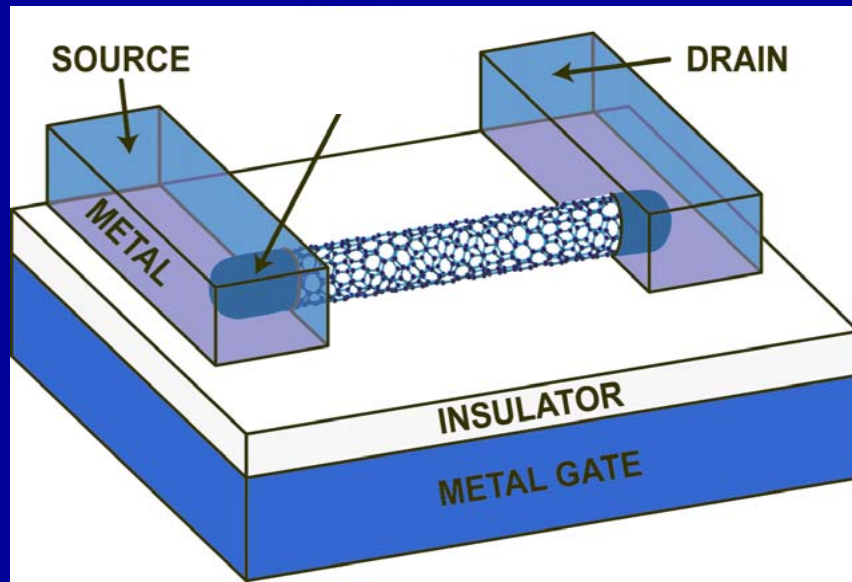
Overview:

Triiodothyranine (T3): Thyroid Hormone

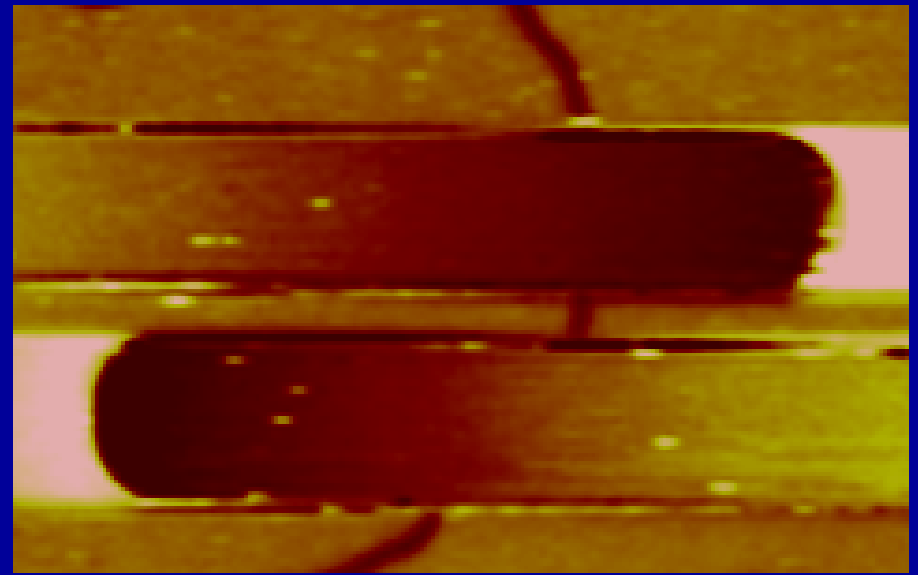


- T3 Essential to early development
 - Iodine atoms biochemically active
 - Plays a role (possibly electrical in nature) in DNA translation
- > Carbon Nanotubes as 1D electrical models for DNA?

Carbon Nanotube Field Effect Transistor (NT-FET) Based Biosensor



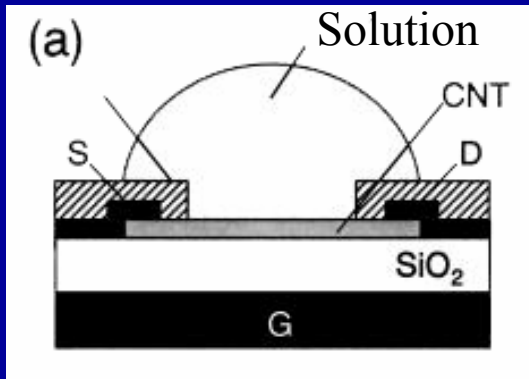
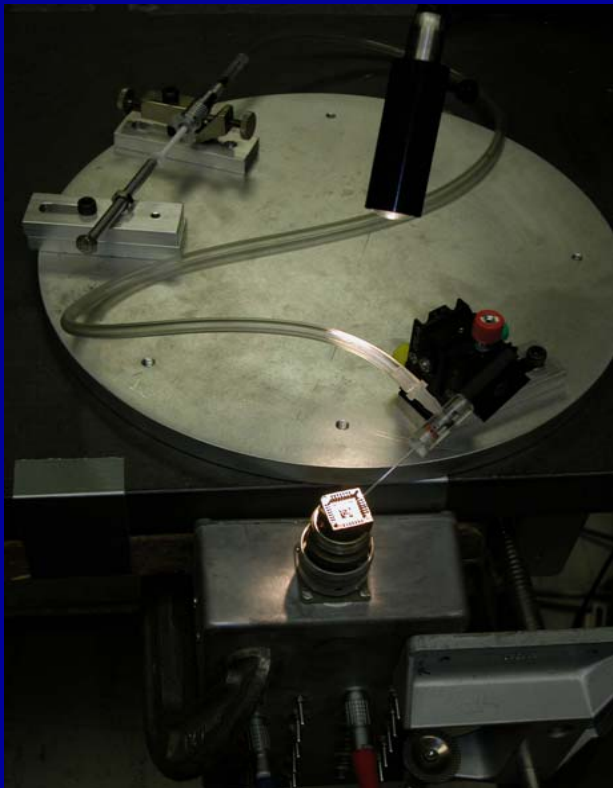
Typical CN-FET Geometry



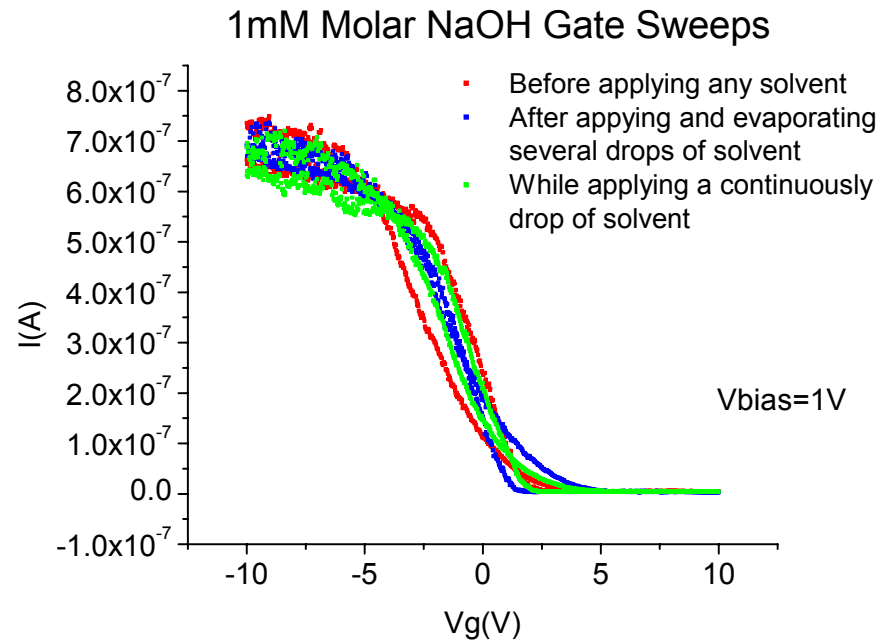
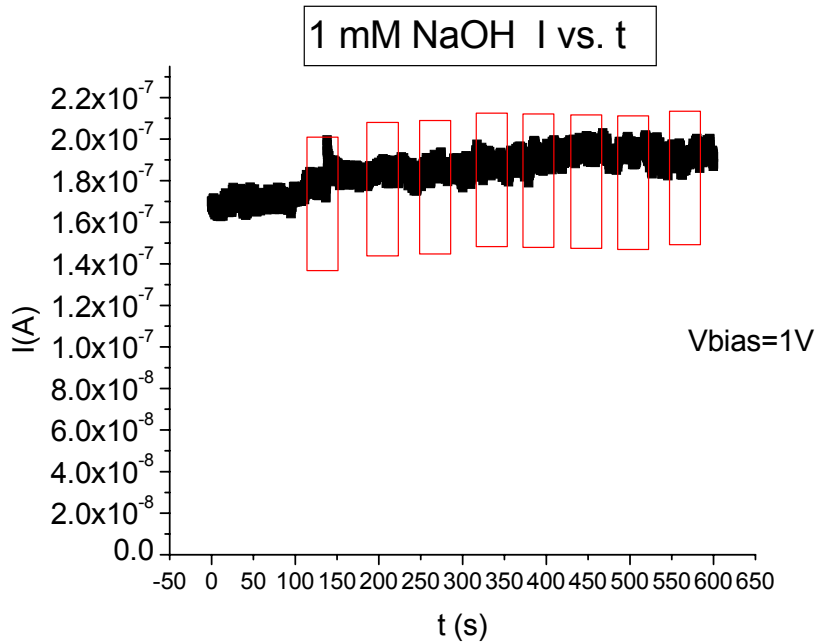
Scanning Conductance AFM Image

Introduction of Biomolecules to NT-FETs

Experimental apparatus allows for precise application of target molecule in solution

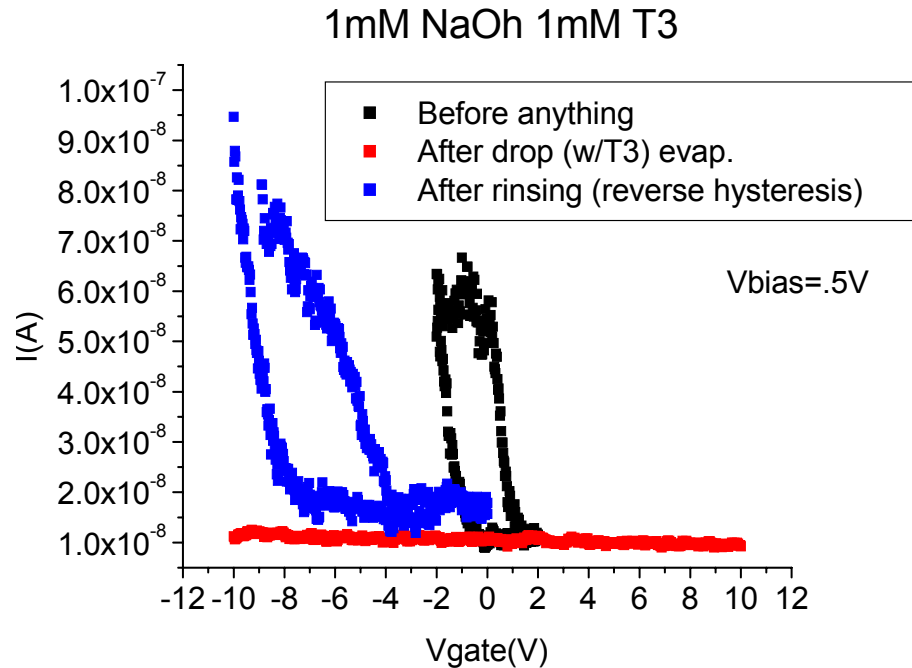
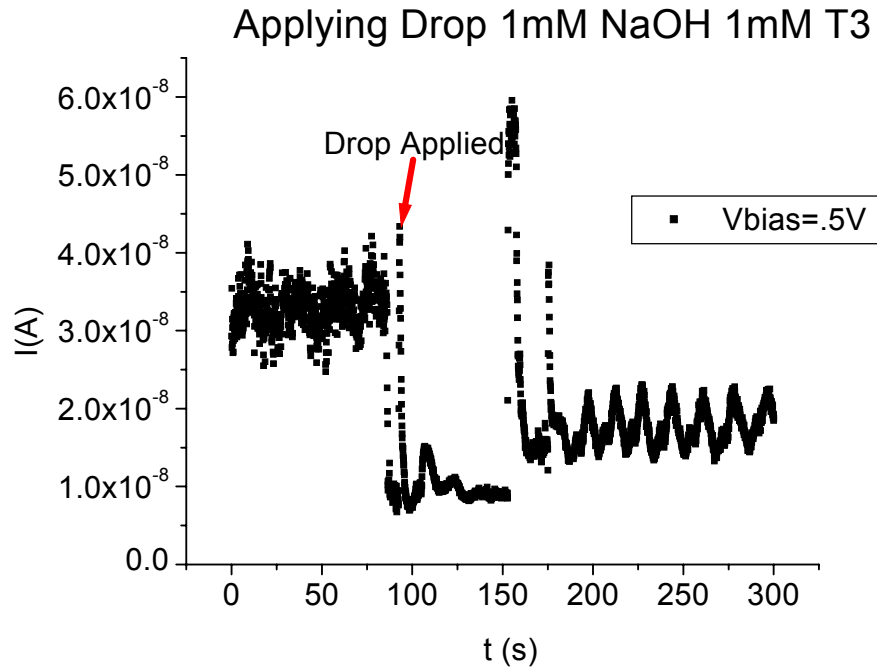


Solvent Control Experiments: NaOH



- No clear correlation between drops and features on plot!
- We can expect little or no signal due to NaOH solution.
- Other solvents, NaOH/Ethanol and DMF, also useful.

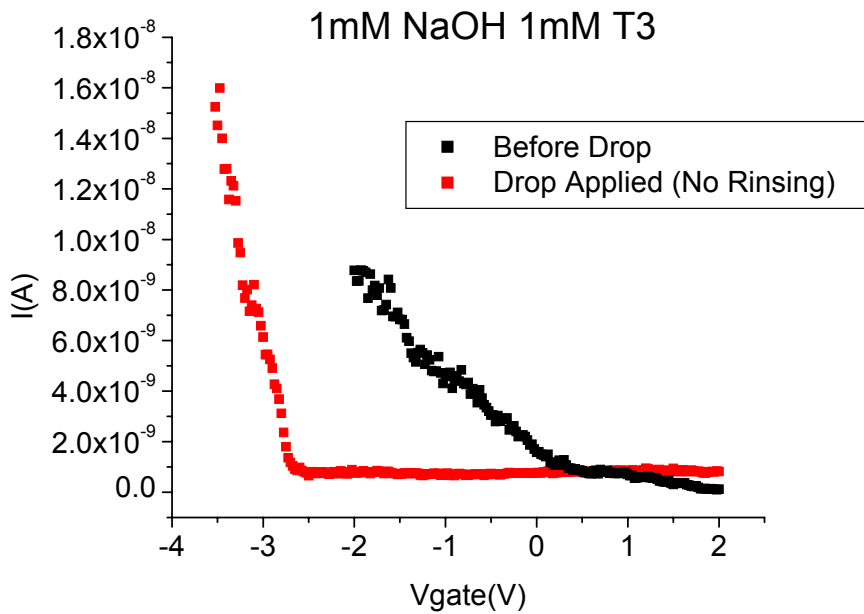
Results with T3 - Device #1



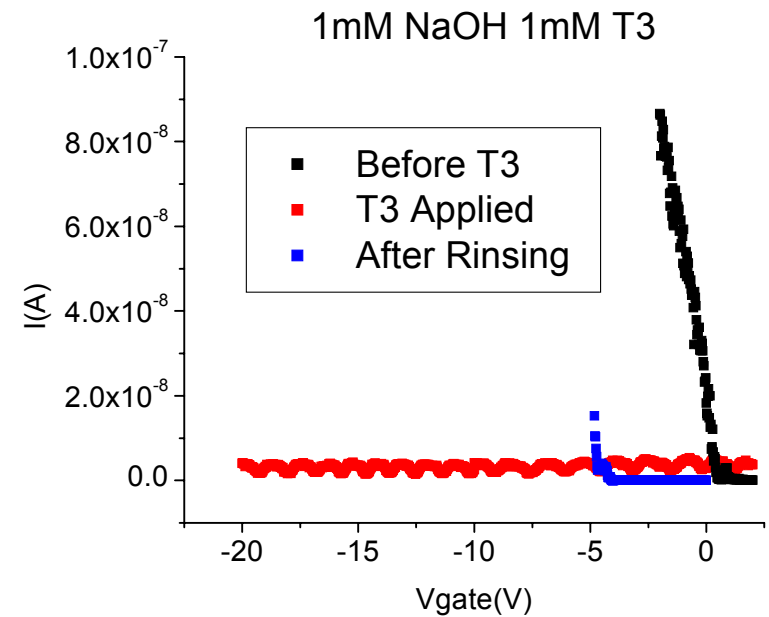
- 1) Partially reversible shift in gate hysteresis.
- or,
- 2) Suppression and recovery of gate response

Results with T3 cont.

Device #2



Device #3



• Supports 1) Shift Theory

• Supports 2) Suppression Theory



Future Directions

- Search for the transistor on-state onset at values of $V_{\text{Gate}} < -30 \text{ V}$.
- Measure gate shift as a function of T3 molarity.
- Tests other solvents.
- Incorporate T3 receptor molecule.

Conclusions

- Biosensor technology has been developed for detection of T3.
- T3 shares an electrostatic interaction with single-walled carbon nanotubes.
- Possible extension to T3 physiology and interaction with DNA.





Thanks:

Experimental Help:

Jonas Goldsmith

Cristian Staii

Funding:

SUNFEST –

Jan van der Spiegel

Lois Clearfield

NSF

Rest of Johnson Group:

Marky Llaguno

Yangxin Zhou

Danvers Johnston

Juro Vavro

Kumhyo Byon

Carl Pfendner

Lynn Daniels

Marc Baron

Saken Kulkarni

And:

Mohammad Islam

Jack Fischer

