COMSOL Day
Orange County

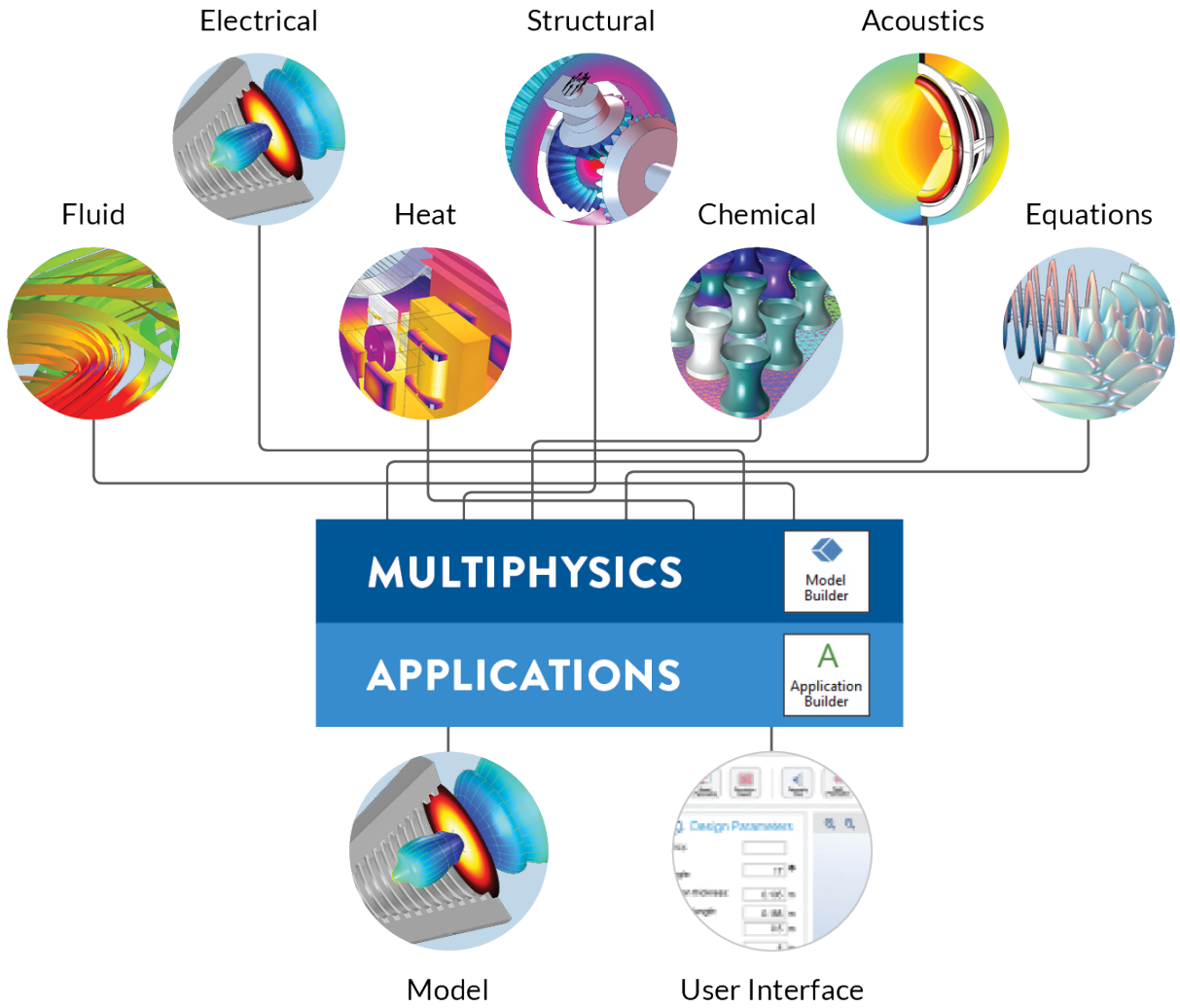
Thursday
May 17, 2018
8:30AM–4:00PM

Bioheating Modeling with COMSOL Multiphysics®

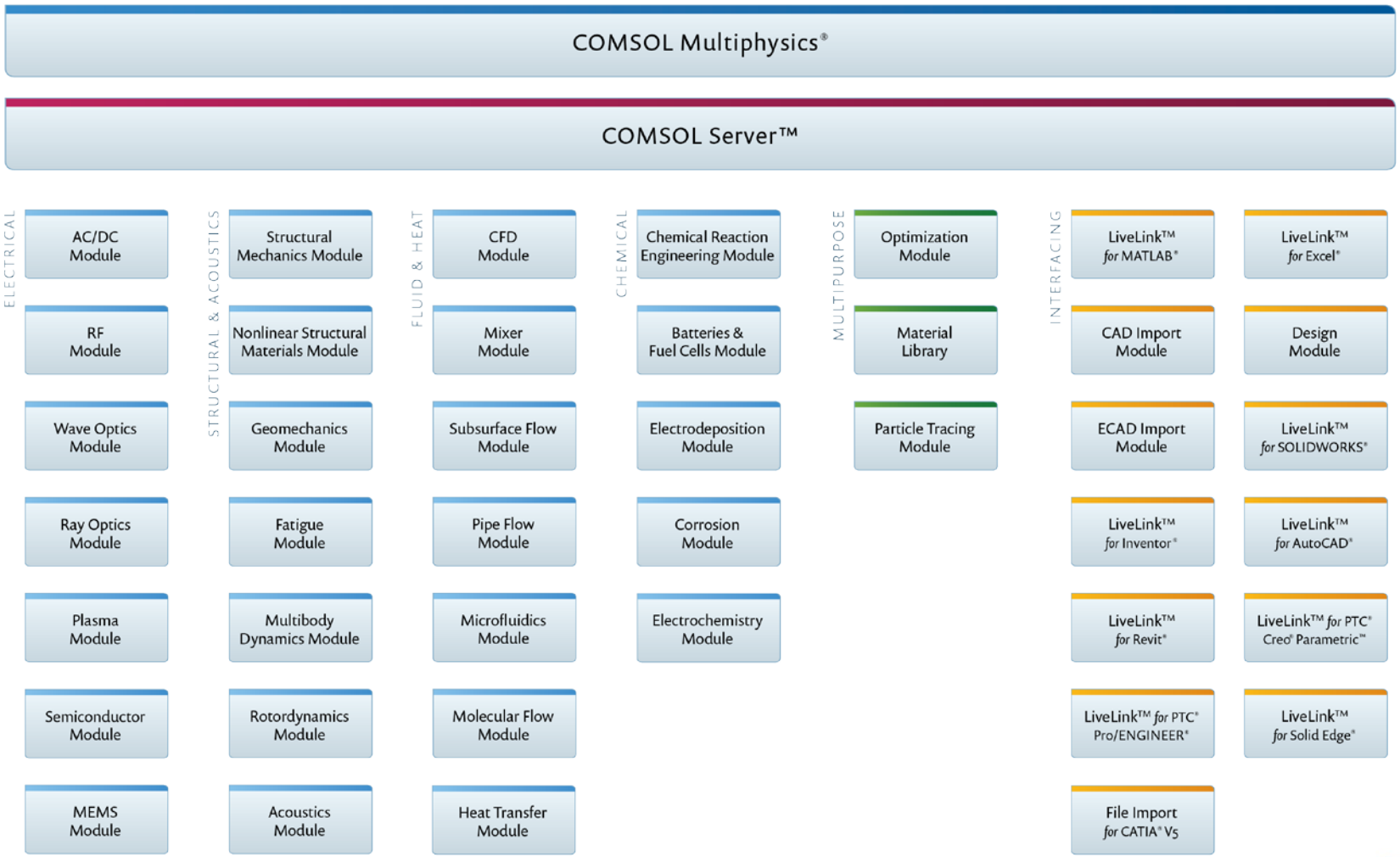
Leo Hwang
Los Angeles, COMSOL, Inc.

COMSOL

COMSOL Multiphysics®

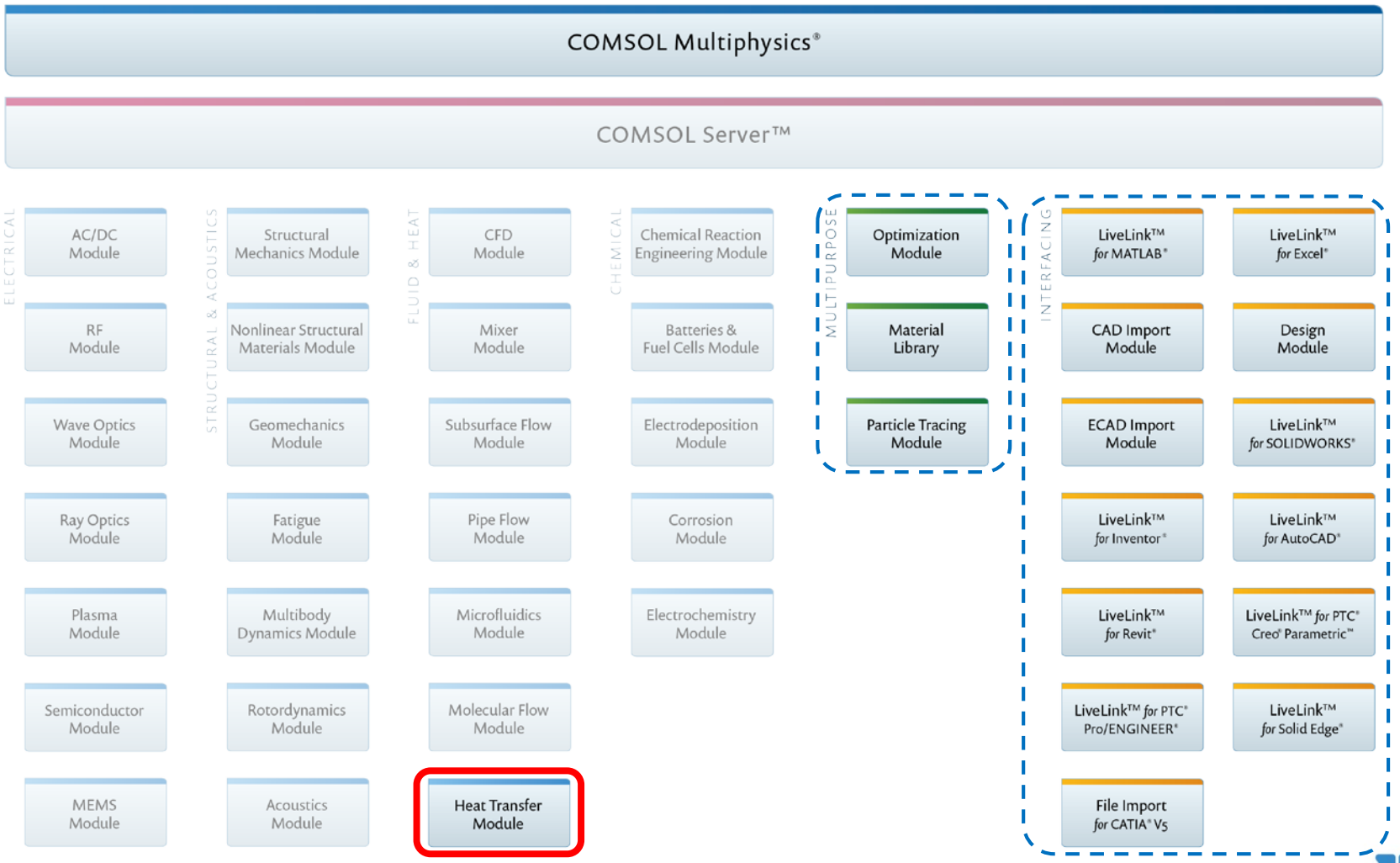


Product Suite – COMSOL 5.3a



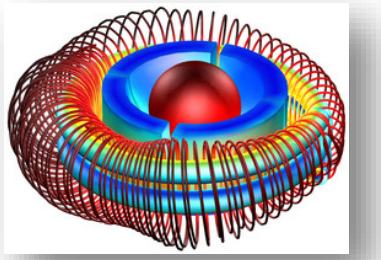
COMSOL

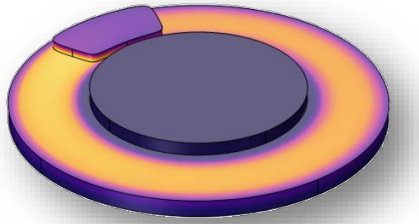
Product Suite – COMSOL 5.3a

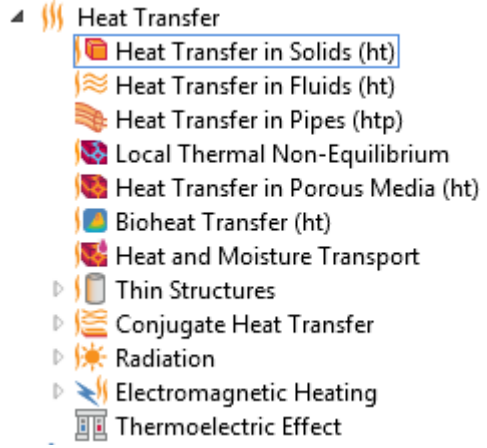


Heat Transfer Module

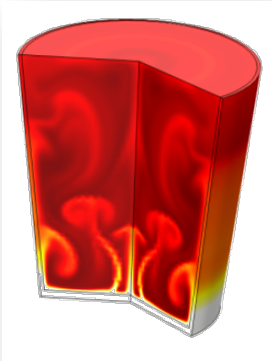
- Module for General-Purpose Modeling of Heat Transfer in Solids and Fluids
  - Conduction
  - Convection
  - Radiation
  - Bioheating

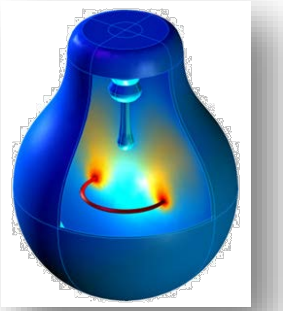


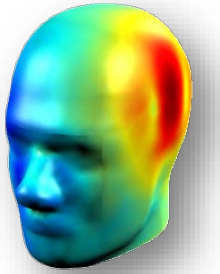


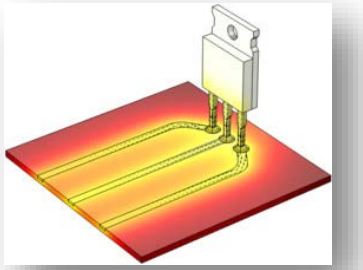


- Predefined Multiphysics Couplings
  - Joule and Inductive heating
  - Microwave heating
  - Heat and Moisture
  - Conjugate heat transfer
  - Phase change
  - Thermal expansion
  - Ray heat





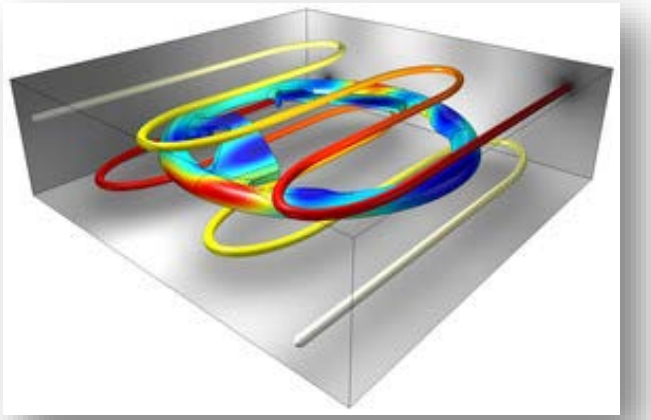


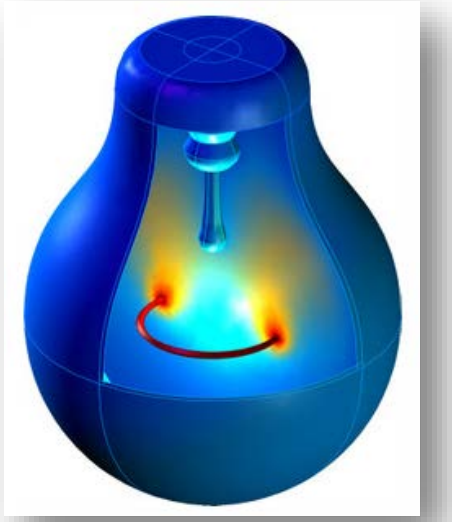


COMSOL

Applications

- Heat Transfer in Fluids
- Isothermal Domains
- Pipe Flow
- Heat Transfer with Phase Change
- Heat Transfer in Porous Media
- Heat and Moisture Transport
- Moisture Flow Multiphysics Coupling
- Heat Transfer in Biological Tissues
- Surface-to-Surface Radiation
- Thermal Contact
- Thermoelectric Effect and many more….

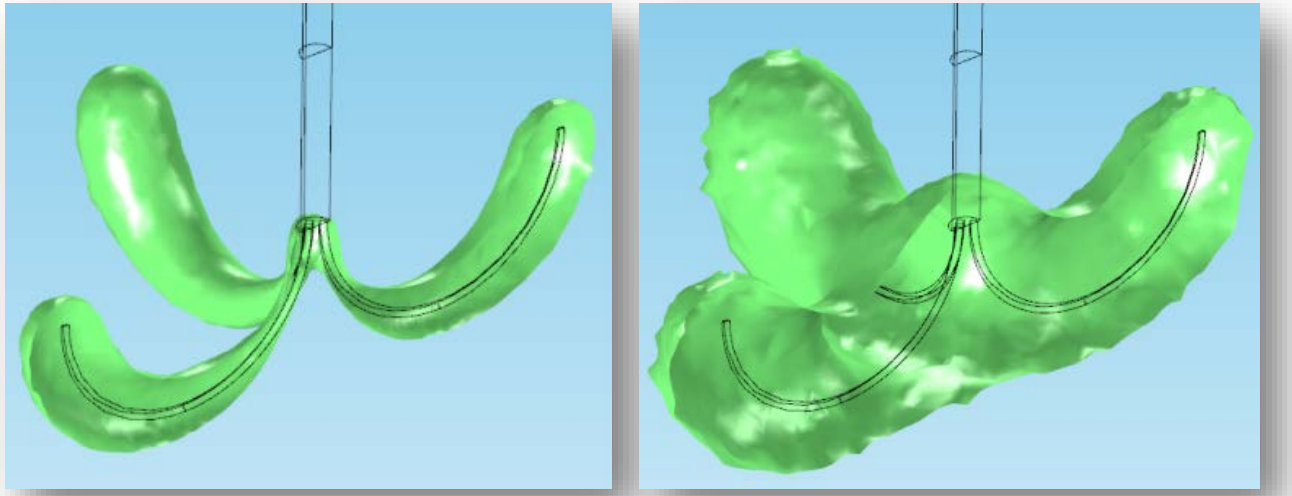




COMSOL

Heat Transfer in Biological Tissues

- Heat transfer in living tissue
  - Tissue and blood properties
  - Blood perfusion rate
  - Arterial blood temperature
  - Metabolic heat rate
- Bioheat source
- Damage in living tissues
  - Temperature threshold model
  - Energy absorption model
  - Cryogenic damage
- External heat sources
  - RF
  - DC current
  - Ultrasound



Tissue necrosis area during tumor ablation process at 100s (left) and 300s (right).

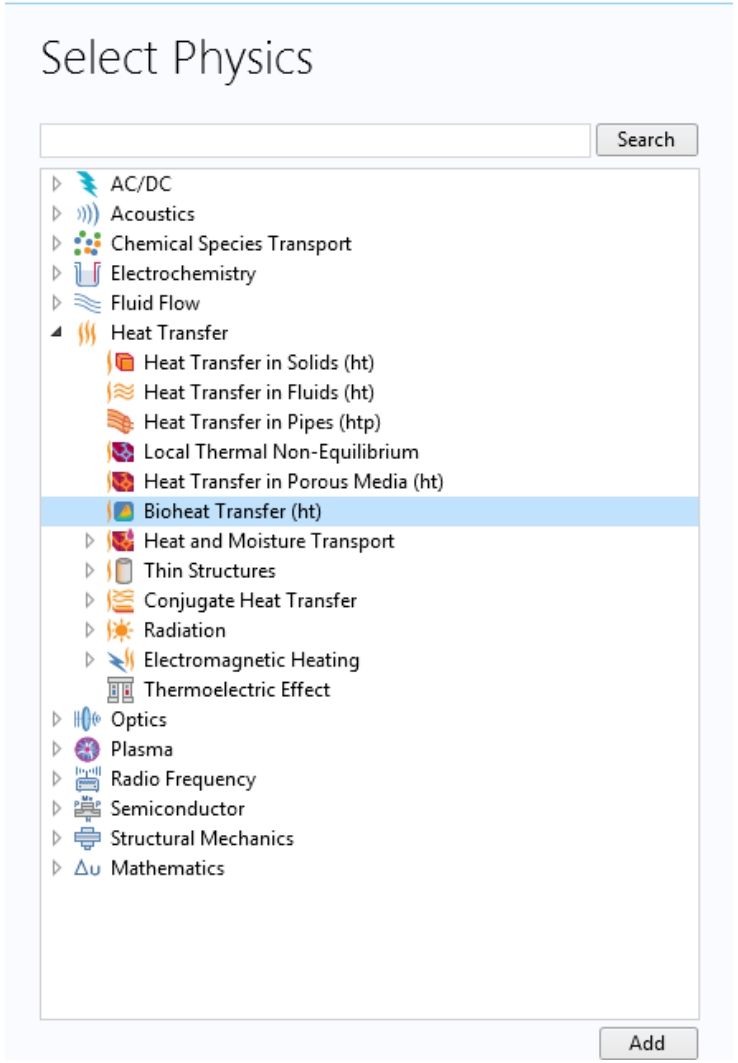
Bioheat Transfer

- Bioheat Equation

$$\rho C_p \frac{\partial T}{\partial t} + \nabla \cdot \mathbf{q} = \rho_b C_{p,b} \omega_b (T_b - T) + Q_{met}$$

- Bioheat Transfer Interface (ht)
  - Domain: Biological Tissue

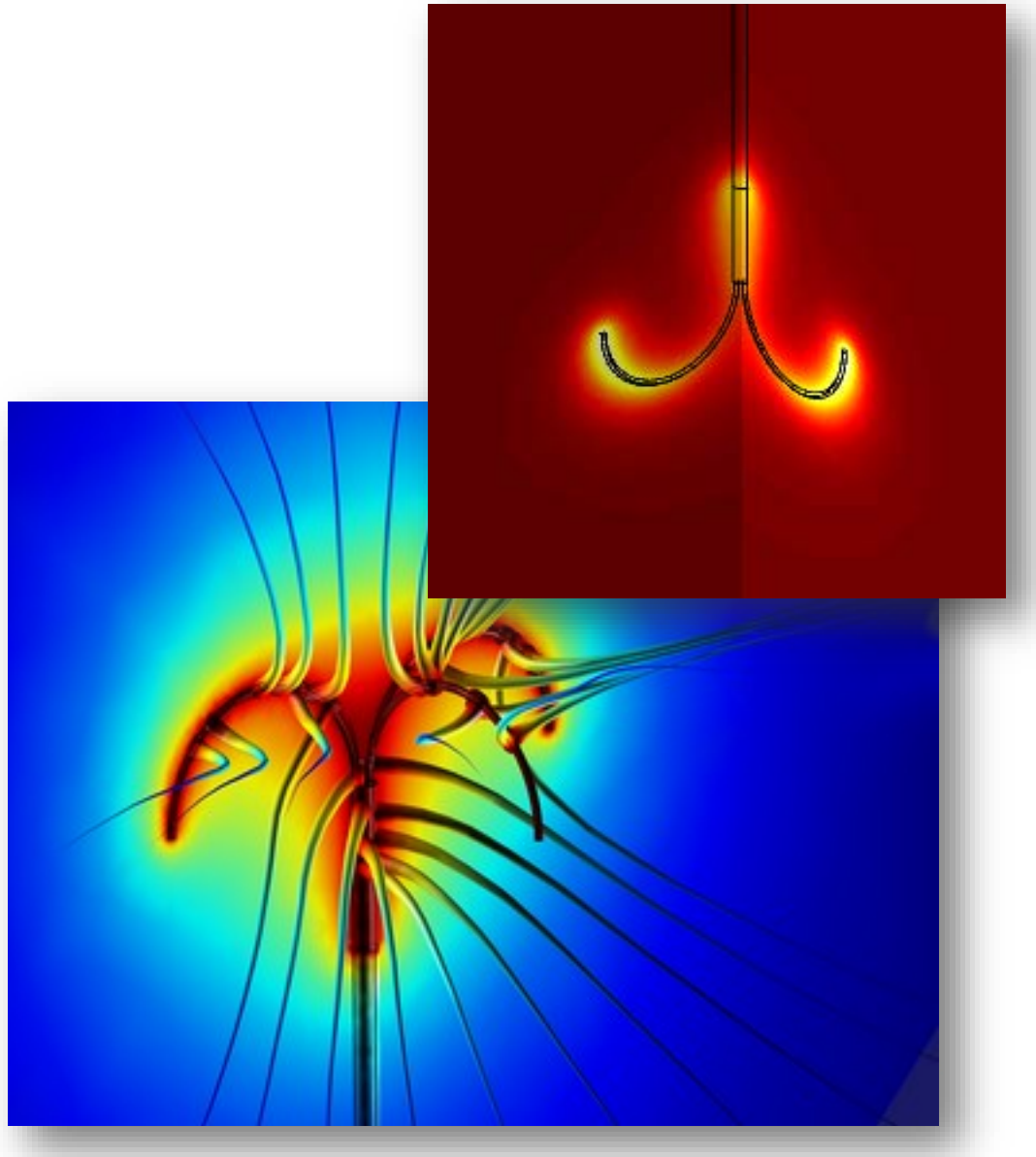
- Damaged Tissue
  - Temperature threshold
  - Arrhenius kinetics
  - User defined



COMSOL

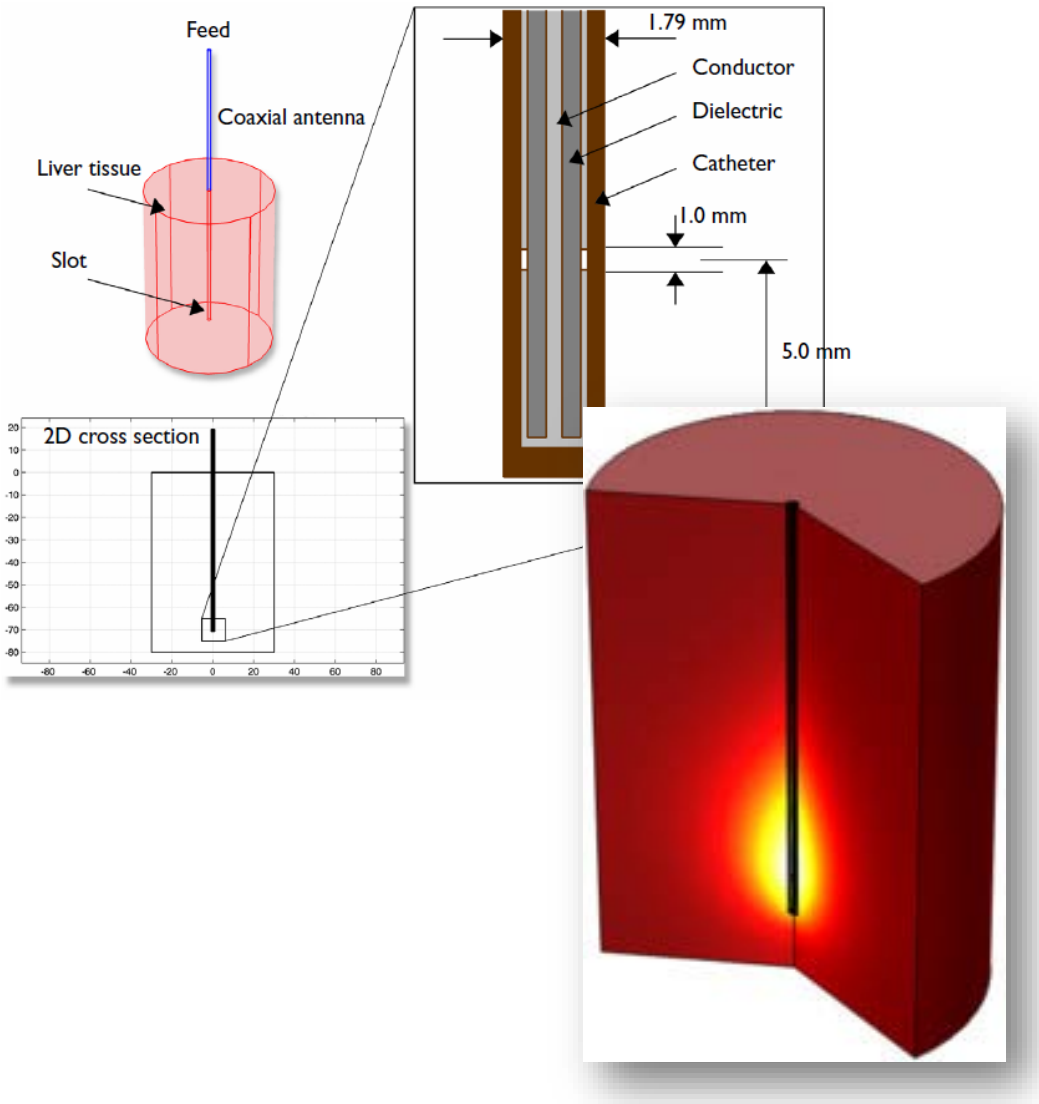
Hepatic Tumor Ablation

- One method for removing cancerous tumors from healthy tissue is to heat the malignant tissue to a critical temperature that kills the cancer cells.
- This example accomplishes localized heating by inserting a four-armed electric probe through which an electric current runs. The heat source is resistive heating or Joule heating.
- This model uses the Bioheat Transfer interface and the Electric Currents interface to implement a transient analysis.
- Damage integral analysis is used to predict the tissue necrosis



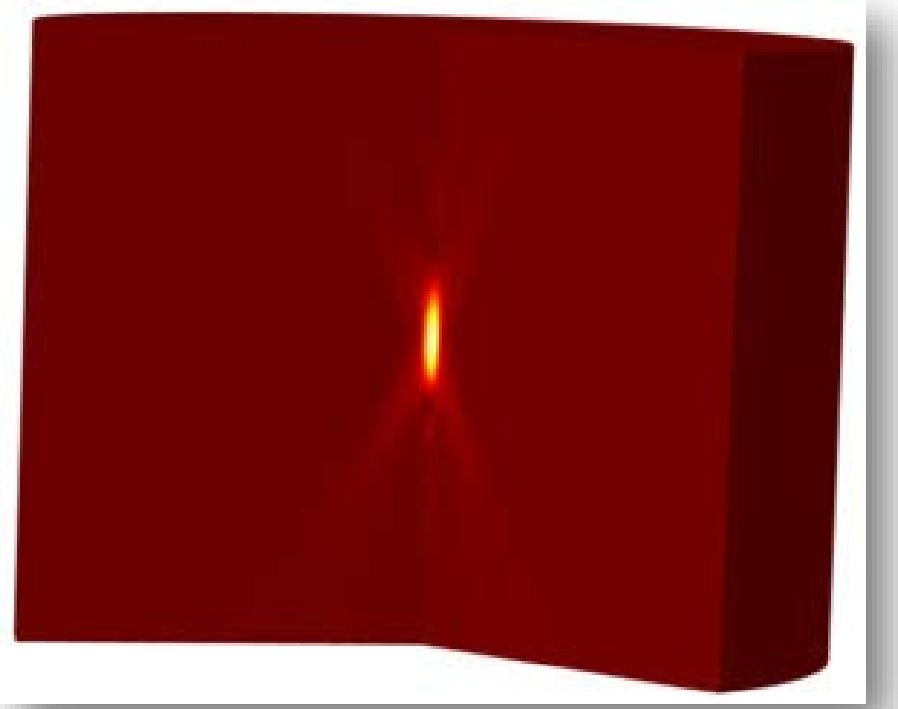
Microwave Heating of a Cancer Tumor

- This model shows the area of hyperthermic oncology but the modeling issues and techniques are generally applicable to any problem involving electromagnetic heating.
- The purpose of this model is to compute the radiation field and the Specific Absorption Rate (SAR) in liver tissue for a thin coaxial slot antenna used in microwave coagulation therapy. A simulation of the resulting temperature distribution in the liver is also included.



Ultrasound Heating in Tissue Phantom

- This model example shows how to model tissue heating induced by focused ultrasound.
- First, the stationary acoustic field in the water and the tissue are modeled to obtain the acoustic intensity distribution in the tissue.
- The absorbed acoustic energy is then calculated and used as the heat source for a Bioheat Transfer physics in the tissue domain in a time-dependent study simulating the heating and cooling of the tissue when exposed to ultrasound for 1 second.



COMSOL

COMSOL Day
Orange County

Thursday
May 17, 2018
8:30AM–4:00PM

Thank you for attending COMSOL Day Orange County!

- Explore COMSOL with the trial
- Check out the extensive content at
  - Application Gallery: www.comsol.com/models
  - COMSOL Blog: www.comsol.com/blog
- COMSOL Conference
  - October 3-5, Boston
- Sales/Licensing contact
  - Mina Sierou: mina.sierou@comsol.com
  - Leo Hwang: leo.hwang@comsol.com
- Technical support contact
  - www.comsol.com/support
  - Email to support@comsol.com

COMSOL