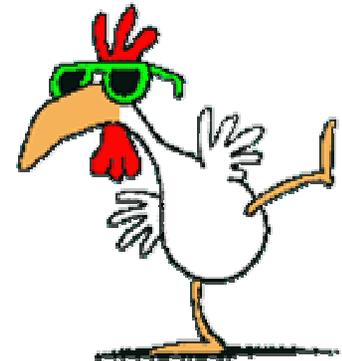


# New Uses for Animal By-Products

*From Basic Science to  
Commercial Products*



*Justin R. Barone  
Presenter*

# A little biology

**Plants and animals are made up of proteins, carbohydrates, nucleic acids, and water.**

Proteins usually comprise major structural components like muscle, joints, skin, hair, and nail.

Carbohydrates usually combine with proteins to form secondary structures in structural components or form primary structures like shell.

Nucleic acids are DNA and RNA and contain our unique genetic information!

**Don't forget the water!**

# Agriculture wants to sell a product



What about the rest of the stuff?

# Each process yields a by-product

Proteins: Casein from milk, Lactalbumin from whey, Gluten from wheat, Albumin from blood, Soy protein, Keratin from feathers.

Carbohydrates: Chitin from shrimp, crab shells, Starch from grains.

Right now, some by-products are viewed as waste problems!

# Problem – feather waste



**Neither is profitable or environmentally-friendly!**

# Just how unfriendly?

A landfill would be 50 feet deep and 980 acres in surface area! You could fill Washington, DC in 39 years.

Landfilling comes at the expense of the poultry producer.

Feather meal at best barely covers the cost to produce it.

Burning for fuel is inefficient.

# What can you do with proteins and carbohydrates?

Proteins and carbohydrates are called **POLYMERS**.

Commercial synthetic polymers are called **PLASTICS** and are derived from petroleum.

What if we could make sustainable, environmentally-friendly **PLASTICS** from agricultural by-products like proteins and carbohydrates?

# Carbohydrates

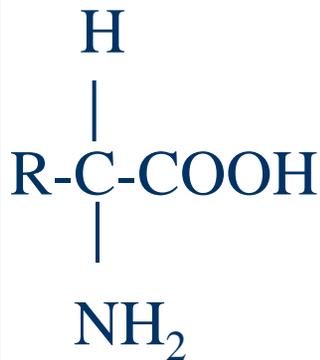
Historically, most research has concentrated on carbohydrates like starch probably because they are very abundant in nature.

Carbohydrate molecules are not very versatile.

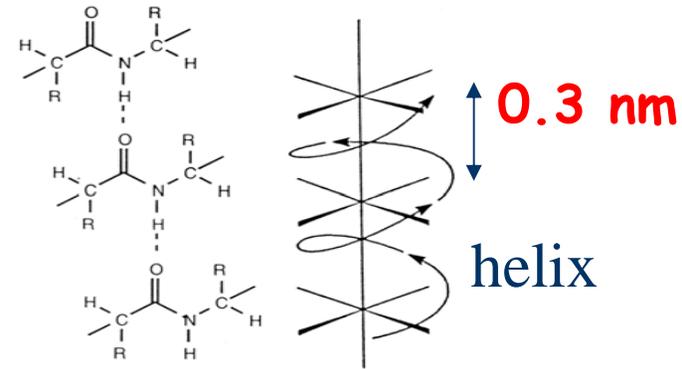
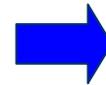
The biggest problem is that carbohydrates are molecules that soak up a lot of water. This limits the usefulness of the product made from them.

# Proteins are a much better solution

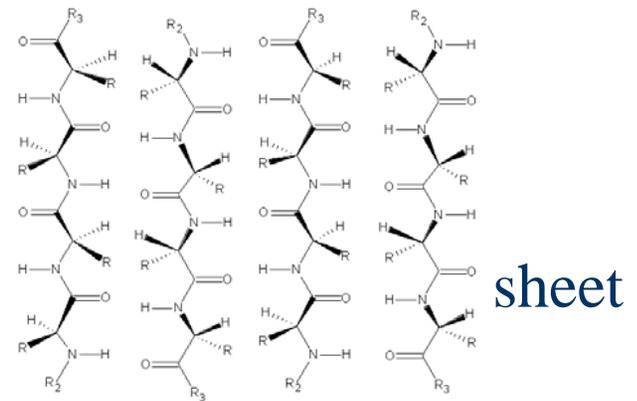
Amino acids



Peptides



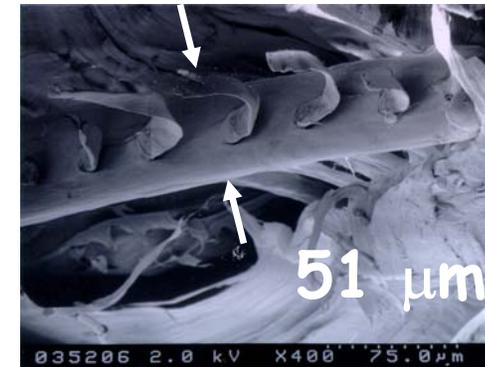
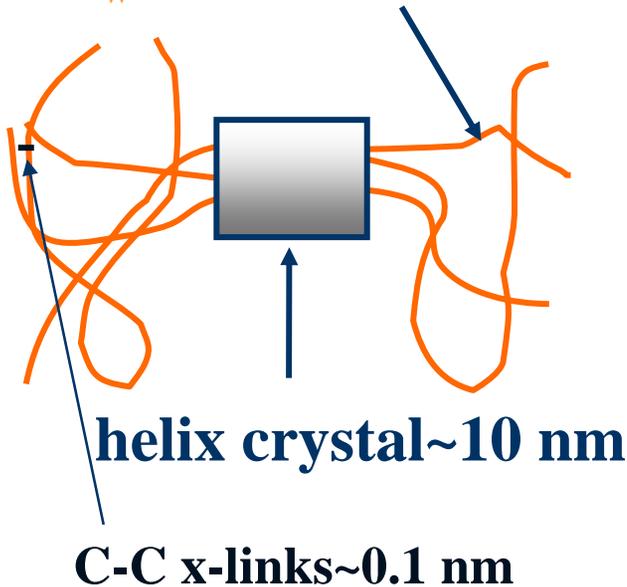
Twenty different amino acids in different sequences means lots of versatility!



Nanostructure

# Unique protein structure of feather keratin

Protein~100 nm  
 $M_w$ ~10,500 g/mol



Proteins can be very soluble or not soluble in water depending on how much structure!

Unique microstructure

# Feather keratin



**A handful of clean material**



**Value-added products!**

**Density = 0.89 g/cm<sup>3</sup>**

**Strength = 200 MPa**

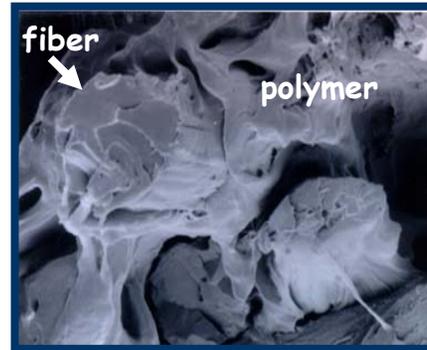
**Stiffness = 5-10 GPa**

# Uses of feather material

## Filters/mats



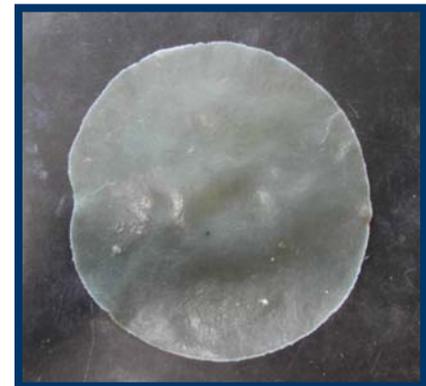
## Composites



## Cosmetics



## Plastics



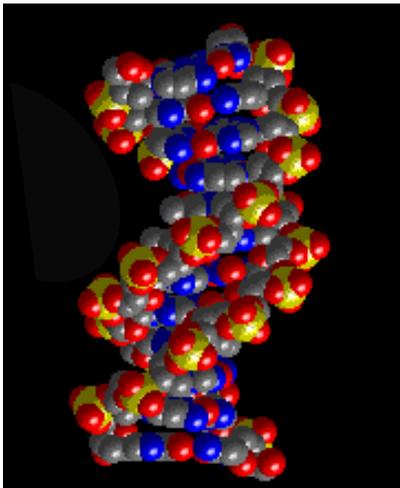
# Markets



High volume,  
Low profit margin



Low volume,  
Moderate profit margin



Very low volume,  
Very high profit margin

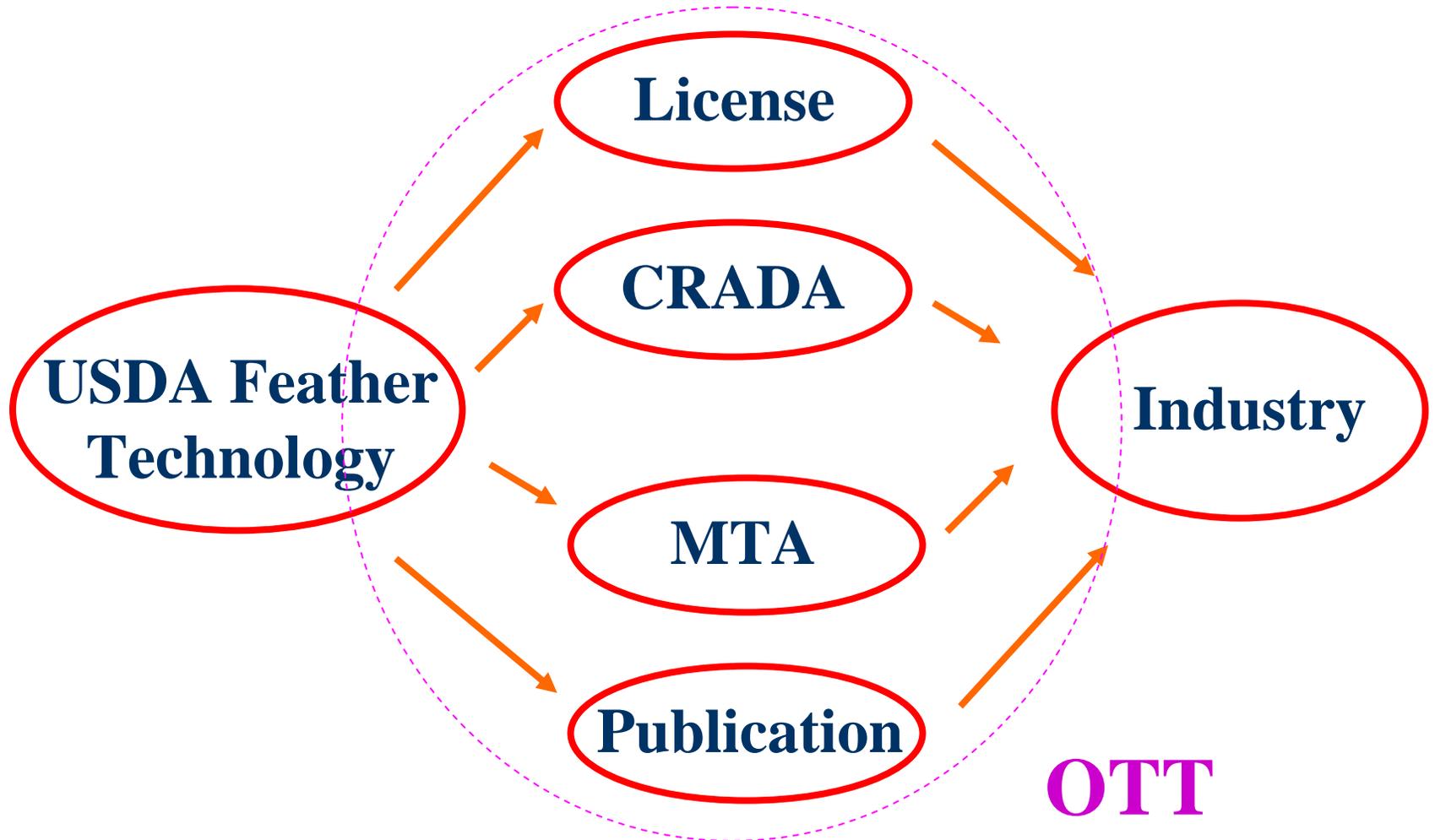
# Markets

Several hundred billion pounds of commodity synthetic (derived from petroleum) polymers and fibers are sold in the U.S. each year.

At 2 billion pounds, feather keratin would be a niche market at best.

What if one great market opened up?

# Technology Transfer = Dissemination of Information



# Our Tech Transfer – Phase I

- US patent awarded in 1998 concerning cleaning and separating feather fiber from quill
- Foreign patents awarded
  - ✓ Brazil, European Union, Japan, China
- Three licenses were awarded
  - ✓ Tysons
  - ✓ Maxim
  - ✓ FeatherFiber
- FeatherFiber has built and operates a pilot plant in Nixa, MO

# Our Tech Transfer – Phase II

- Two new patents on making composites (applied) and keratin polymers (pending). Currently seeking licensees.
- Present and publish important results.
- CRADA's with several small and large companies have been signed or are being negotiated.

# Industrial Partners



**License**  
**Featherfiber Corporation**

**CRADA**  
**Tyson Foods**

**Potential Partners**  
**ANLA**

# Success story: Tyson/USDA collaboration

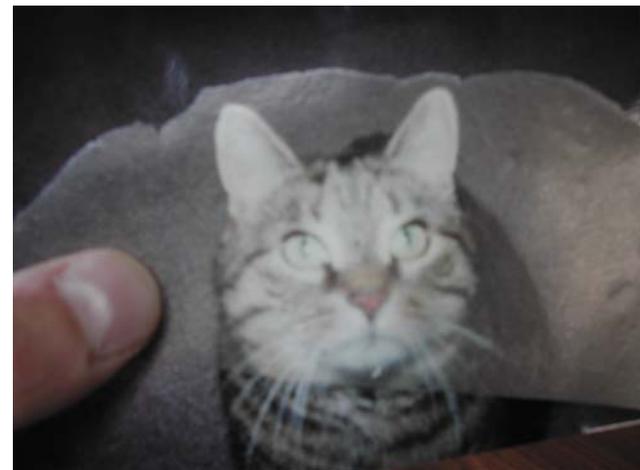
Tyson is a large meat processor. So, they suffer from all of the waste problems associated with poultry and beef production.

Can the feathers be used in a profitable way?

Biodegradable mulching films, nursery containers, packaging.

Pilot scale testing, market analysis underway.

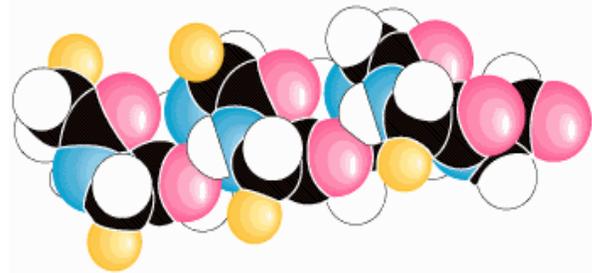
# Extruding keratin polymer



# Molded keratin items



*Questions?*



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