Researchers Chu the Fat

"Cholesterol...Omega-3 fatty acids...nutritional quality...diet."

Anyone catching these snippets of conversation between Drs. Fu Lin Chu and Kam Tang might think the two were medical doctors advising an obese patient.

Instead, it turns out the pair of VIMS researchers are discussing their pioneering study of "trophic upgrading," which Chu describes as "the process by which certain single-celled organisms transform the poor quality algae they eat into the essential fatty acids and sterols that their predators require."

Essential fatty acids, or EFAs, are important in many metabolic processes. Sterols—a class of compounds that contains cholesterol as well as less familiar substances like stigmasterol and brassicasterol—are key components of cellular membranes.

Chu, Tang, Asst. Research Scientist Eric Lund, and recent Masters student Adriana Veloza are among only a handful of researchers worldwide studying trophic upgrading, a process now thought to play a key role in boosting the quality of nutrients as they pass from the base of the marine food web up to fish, shellfish, and ultimately, humans.

Marine scientists have traditionally viewed the bottom rung of the marine food chain as a relatively simple transfer of elements—notably nitrogen, phosphorous, and carbon—from photosynthetic algae to copepods and other zooplankton grazers.

This elemental approach has proven useful for understanding the basic workings of the ocean food web, but it cannot resolve certain questions in marine ecology.

One such question is how calanoid copepods (the dominant copepod group in the sea) obtain the EFAs and sterols they need for reproduction and growth. Like many other animals, calanoid copepods are unable to make these compounds themselves; instead relying on food items to supply their metabolic needs.

But therein lies the rub—although planktonic algae are the main producers of EFAs and sterols in marine systems, many algal species do not contain the quantity or type of EFAs or sterols that the copepods require.

"Traditional thinking holds that food quality is not an issue for zooplankters in the marine environment," says Chu. "In this view, the presence of diverse food types will inevitably provide complete biochemical nutrition for zooplankton production."

"But in reality," she continues, "the make-up of the algal community varies seasonally and regionally. At times, it is dominated by poor quality species that are deficient in EFAs and sterols."

Field and laboratory experiments show that copepods that eat low-quality algae—the planktonic equivalent of junk food—grow more slowly, lay fewer eggs, and suffer higher mortality. Poor health among copepods may in turn reverberate up the food chain, as the larvae and juveniles of many fish depend on copepods for growth and sustenance.

If copepods cannot always get sufficient EFAs and sterols from algae, then where do they get them? The missing link appears to be a group of organisms called "heterotrophic protists." These single-celled creatures are related to photosynthetic algae, but do not make their own food from sunlight. Instead, they consume the algae that do, and are in turn themselves preyed on by copepods.

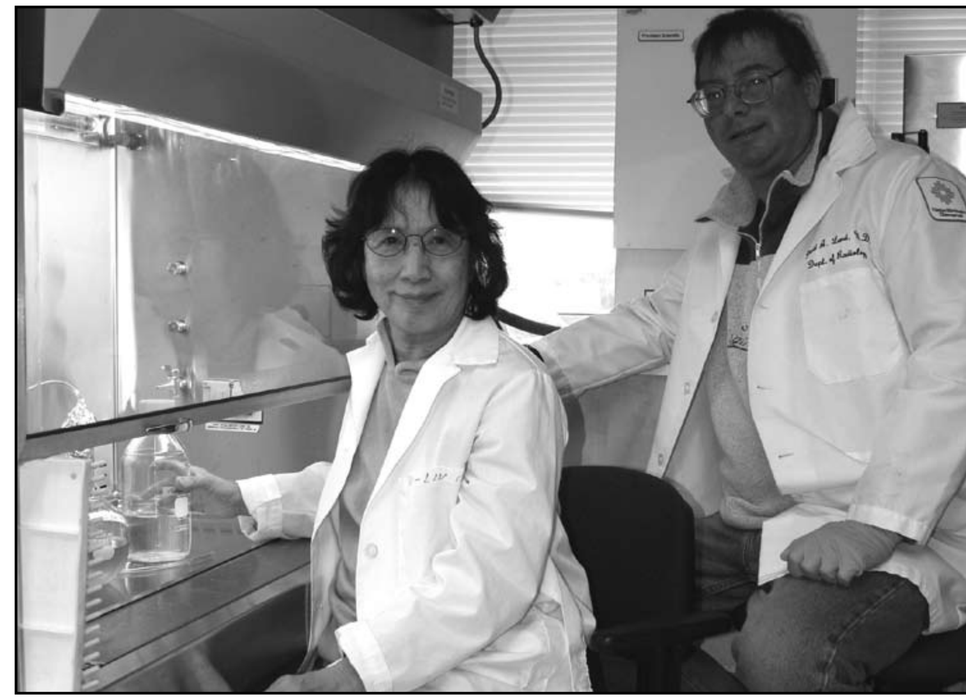
Research by Chu's group and other investigators shows that certain species of heterotrophic protists can improve the fatty acid content of their algal food by either upgrading the low-quality fatty acids already present in the algae, or by synthesizing EFAs and sterols from scratch. Some species can do both.

Says Chu, "Our analysis of protist predators and algal prey reveals that EFAs and sterols that are not present in the prey are present in the predators, and that the predators have elevated levels of these compounds when fed with algae that do contain them."

Thus, for heterotrophic protists, the adage "you are what you eat" is only partly true. Indeed, the ability of some types to synthesize "essential fatty acids" from scratch refutes the very definition of the term, as EFAs are typically defined as compounds that cannot be synthesized by an organism and must be supplied from dietary sources.

Trophic upgrading has important implications for marine food webs. "It's clear that heterotrophic protists can determine the levels of EFAs subsequently available to higher levels of the food chain," says Chu. "Their nutritional quality can exceed that of their algal food, and as prey, they can in turn support higher growth in copepods and fish."

To date, research by Chu's group has confirmed the process of trophic upgrading in experiments using two common species of heterotrophic protists, a pair of common algal species, and a single species of copepod from the York River. However, not all protists are capable of trophic upgrading, and the biochemical mechanisms of the process remain unknown.



Drs. Fu-Lin Chu and Eric Lund study the process of trophic upgrading in their Chesapeake Bay Hall laboratory.

"These observations show that nutrient dynamics between algae, heterotrophic protists, and zooplankton are complex and variable," says Chu. "To fully understand the planktonic food web, we need detailed studies of the biochemical processes by which trophic upgrading occurs in different species."

A new National Science Foundation grant to Chu, Lund, and Tang will allow the trio to do exactly that. They will use the 3-year, $525,000 grant to define the specific biochemical pathways by which six heterotrophic protists metabolize and transform EFAs and sterols, and the potential ecological effects on zooplankton production and nutrient cycling.

They will explore the biochemical pathways of trophic upgrading using stable-isotope "tracers," a method Chu and Lund developed and refined during a previous NSF-funded study of the oyster parasite *Perkinsus marinus*.

Chu, Lund, and Tang are also planning future studies to extend their research into the field, where they will investigate the seasonal and geographic correlation between nutrient dynamics and the make-up of the planktonic community.

"Field studies," says Chu, "will help unify our understanding of plankton biochemistry and its effects on a fishery. Fish, especially larvae and juveniles, require high levels of EFAs for optimum growth and development."

The planned study builds on a previous project in collaboration with Hampton University, which explored how plankton composition and nutritional quality affected the growth of young winter flounder.

VIMS graduate student Eric Brasseur took first place in VIMS' 7th Annual Photography Contest for this image of a sea nettle in the York River. Second place went to Lionel Dégremont for his photo of a sponge-encrusted oyster reef; Dean Grubbs took third place for his "Silhouette of an Adult Caribbean Reef Shark." View the winners and honorable mention candidates at www.vims.edu/topstories