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# The Raw and the Cooked

## Introduction

An enjoyable and straightforward demonstration that illustrates denaturation of proteins and introduces the concept of protein structure.

## Concepts

- Denaturation of proteins
- Protein structure

## Materials

Isopropyl alcohol, 70% soln., 20 mL

Beakers, 250-mL, 3

Nitric acid,  $\text{HNO}_3$ , 3.0 M, 10 mL

Eggs, large, 6

## Safety Precautions

*Isopropyl alcohol is a flammable liquid, and is toxic by ingestion and inhalation. Do not store or dispense near heat or open flame. Nitric acid and its solutions are corrosive and are strong oxidizers, store in a separate, isolated section of your acid cabinet. Wear chemical splash goggles, chemical-resistant gloves and aprons. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.*

## Preparation

Separate egg whites from the yolks, placing three egg whites in each of the two 250-mL beakers. The remainder of the egg may be discarded.

## Procedure

1. Pour 20 mL of isopropyl (rubbing) alcohol solution into one beaker containing egg whites. Upon addition of the alcohol, some of the "white" will begin solidifying and turn white (opaque) as it does when an egg is cooked (although not nearly as dramatically).
2. Pour 10 mL of 3.0 M nitric acid solution into the other beaker containing egg whites. Again, the "white" will begin to solidify and turn white, this time somewhat more-so than with the alcohol solution.
3. The denatured egg will be difficult to see, so you may wish to carry the beaker around your classroom so all students may observe the difference.

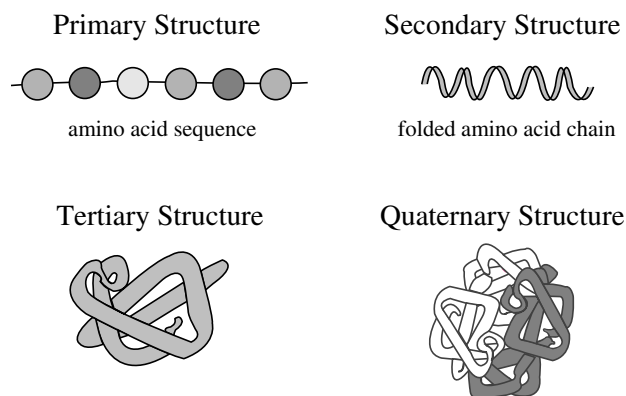
## Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. For disposal of isopropyl alcohol and its solutions (including the egg white/isopropyl mixture), pour the alcohol into a shallow dish or pan and allow to evaporate under a fume hood. Nitric acid solutions should be neutralized under a fume hood with 1 M sodium carbonate solution until no more gas is evolved. The resulting solution can then be flushed down the drain with excess water according to Flinn Suggested Disposal Method #26b. The eggs may be thrown away.

## Discussion

The primary structure of a protein, that is the sequence of its amino acids, is only partially responsible for determining its type and function. The secondary ( $2^\circ$ ), tertiary ( $3^\circ$ ), and quaternary ( $4^\circ$ ) structure of a protein defines its three-dimensional shape and eventual function. The primary structure of a protein is its sequence of amino acids. The secondary structure is the shape a protein takes on by twisting or bending. A protein's tertiary structure is achieved when the secondary structure folds back on itself. The tertiary structure determines the three-dimensional shape and the function of the protein. In some proteins, multiple tertiary structures join to form an active quaternary structure. See the figure below for a diagram of these structures.

### Structure of a Globular Protein



Fibrous proteins are found in hair, fingernails, animal claws and fur among other things. These proteins are strong because the individual protein molecules form parallel strands which twist together. Globular protein molecules work differently. A globular molecule twists and folds upon itself, using hydrogen bonds to join its segments in small spheres (or "globs"). Most of the things that we think of as a protein (meat, muscles, etc.) are globular. Globular proteins are more chemically and physically active. Enzymes are one example of globular proteins.

When a protein is altered from its native structure, it is said to be denatured. This is what happened to the egg white in this demonstration (and when an egg is cooked). In this situation, the egg protein, which is globular, was denatured when its hydrogen bonds (the bonds which hold its subunits together) were broken by the acid or alcohol. The denatured proteins then arrange into different shapes and form the solid white material similar to cooked egg. This denaturation does not occur in fibrous proteins because its bonds are protected by the twisted nature of their  $3^\circ$  and  $4^\circ$  structures.

## Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

### **Unifying Concepts and Processes: Grades K–12**

Evidence, models, and explanation

### **Content Standards: Grades 5–8**

Content Standard B: Physical Science, properties and changes of properties in matter

Content Standard C: Life Science, structure and function in living systems

### **Content Standards: Grades 9–12**

Content Standard B: Physical Science, structure and properties of matter, chemical reactions

Content Standard C: Life Science, the cell

## Reference

Snyder, Carl H. *The Extraordinary Chemistry of Ordinary Things*; Wiley: New York, 1992; pp. 400–401, 418–419.

**Materials for *The Raw and the Cooked* are available from Flinn Scientific, Inc.**

Catalog No.	Description
I0021	Isopropyl alcohol, 70%
N0049	Nitric acid solution, 3.0 M

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.