

***THE APPLICATION OF GENOMIC BIOTECHNOLOGY
TO AQUACULTURE WILL BE ESSENTIAL TO MEET
PRESENT AND FUTURE GLOBAL DEMAND FOR FISH
PROTEIN***

***APLICAÇÃO DA BIOTECNOLOGIA GENÔMICA PARA
AQUACULTURA É ESSENCIAL PARA ATENDER A
PRESENTE E FUTURA DEMANDA MUNDIAL
DE PROTEÍNA DE PEIXE***



What are Some of the Ways Science Can Help Increase the Production of Tilapia

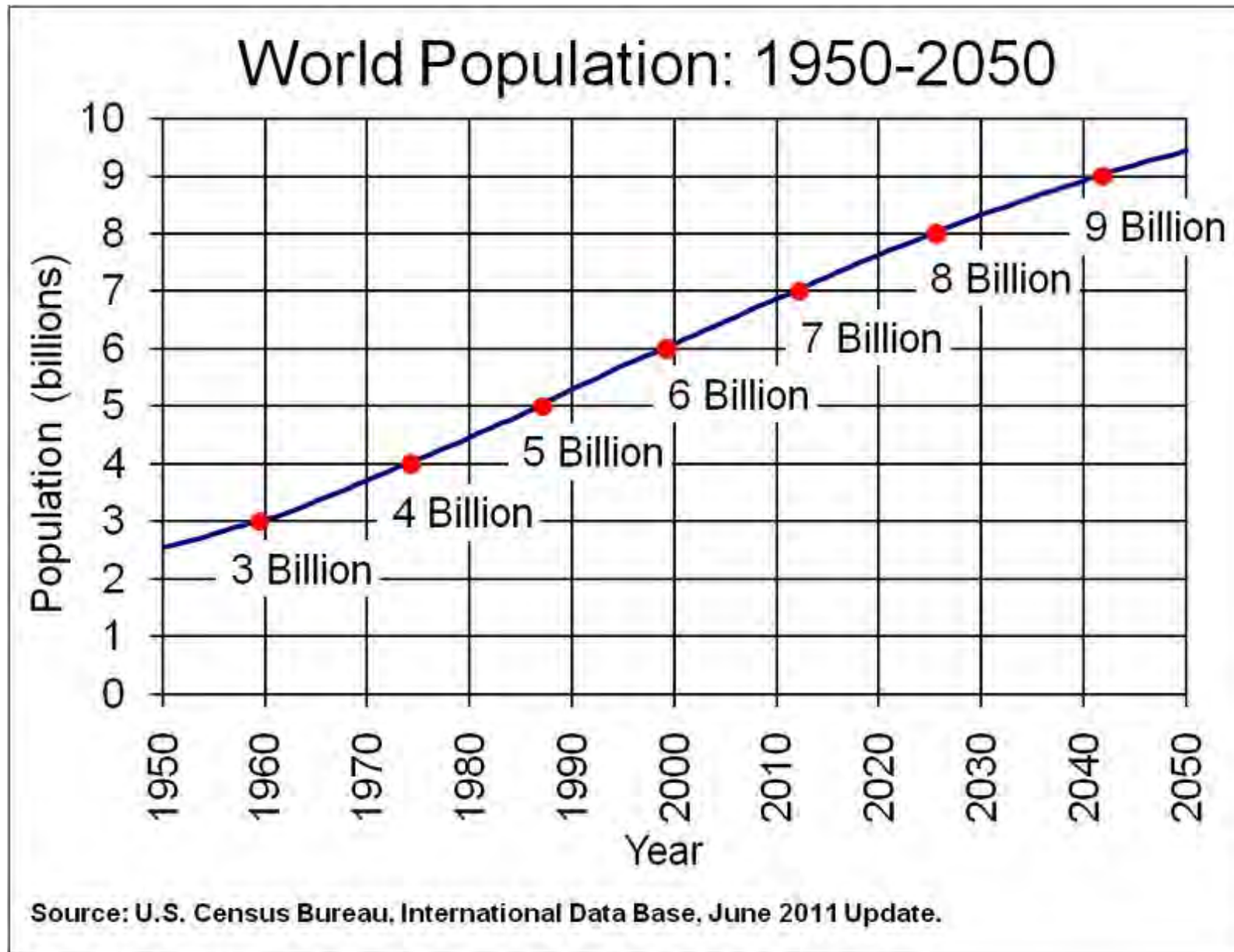
How Can Science Help Increase the Nutritional Value of the Fish Produced



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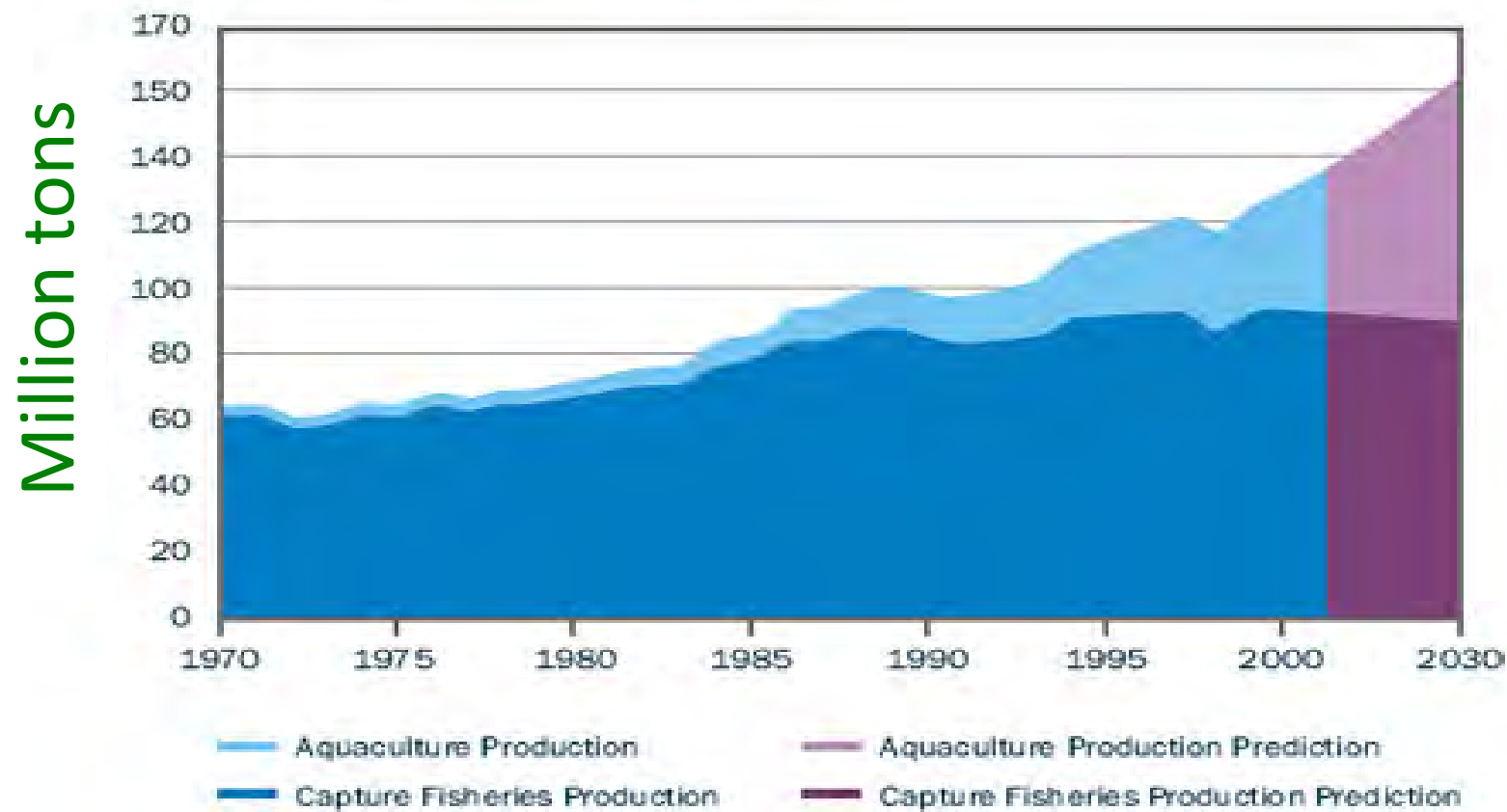
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The Global Population Is On The Rise



Global Need for Aquaculture

World Fish Production



<http://www.aquaculture.ca/files/opportunity-expansion.php>

Meeting Global Demand Using Tilapia

- **Beyond bringing more water resources in to elevated production, what else can be done to increase the production of Tilapia?**
- **If Tilapia can be made to: (1) grow bigger, faster and (2) made more nutritious, this could help to provide protein and other dietary requirements to the world's poor.**
- **The use of Genetic Improvement (GI) can help to close this gap and this is the subject of this talk.**

Tilapia??



How Are GI Fish Created?

Creating Transgenic Lake Sturgeon

Similar to "Selective Breeding"



**Lake Sturgeon are Almost Extinct in
Many of the States Where They Lived.**

**This has been Caused by Illegal Fishing
and then Selling Fillets in Commercial
Markets Where the Species Source is
Difficult to Identify**



**We Created GI Lake Sturgeon
Carrying a Color Producing Gene
from Bacteria as a Means to
Identify Fillets in the Marketplace**



Hydro-Quebec, Montreal, Canada



Some of the lake sturgeons (*Acipenser fulvescens*) were caught here, eggs and milt collected, the eggs fertilized and then taken to another facility where they were transformed with the lac Z gene.



Crews carrying the sturgeon on stretcher.

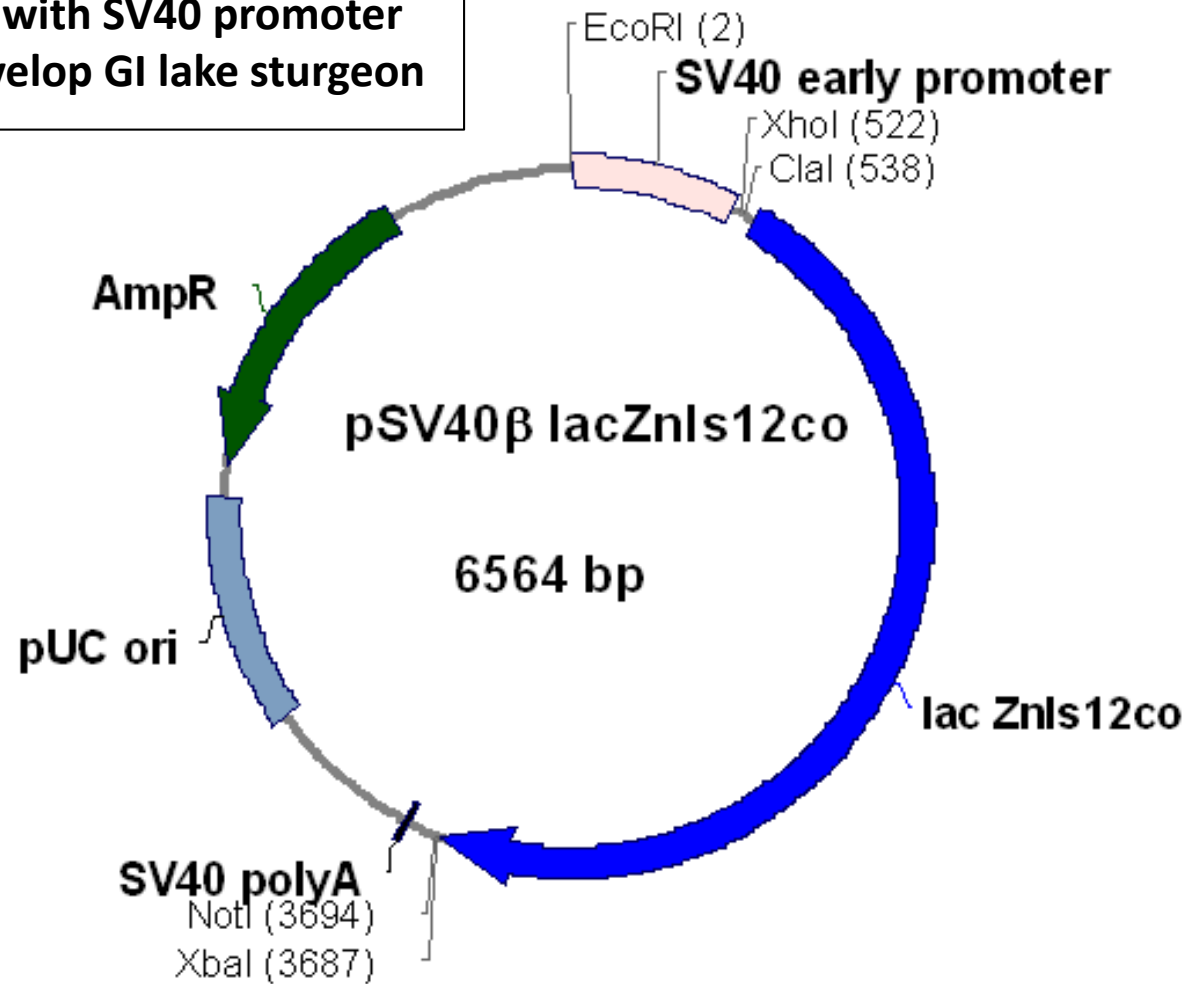


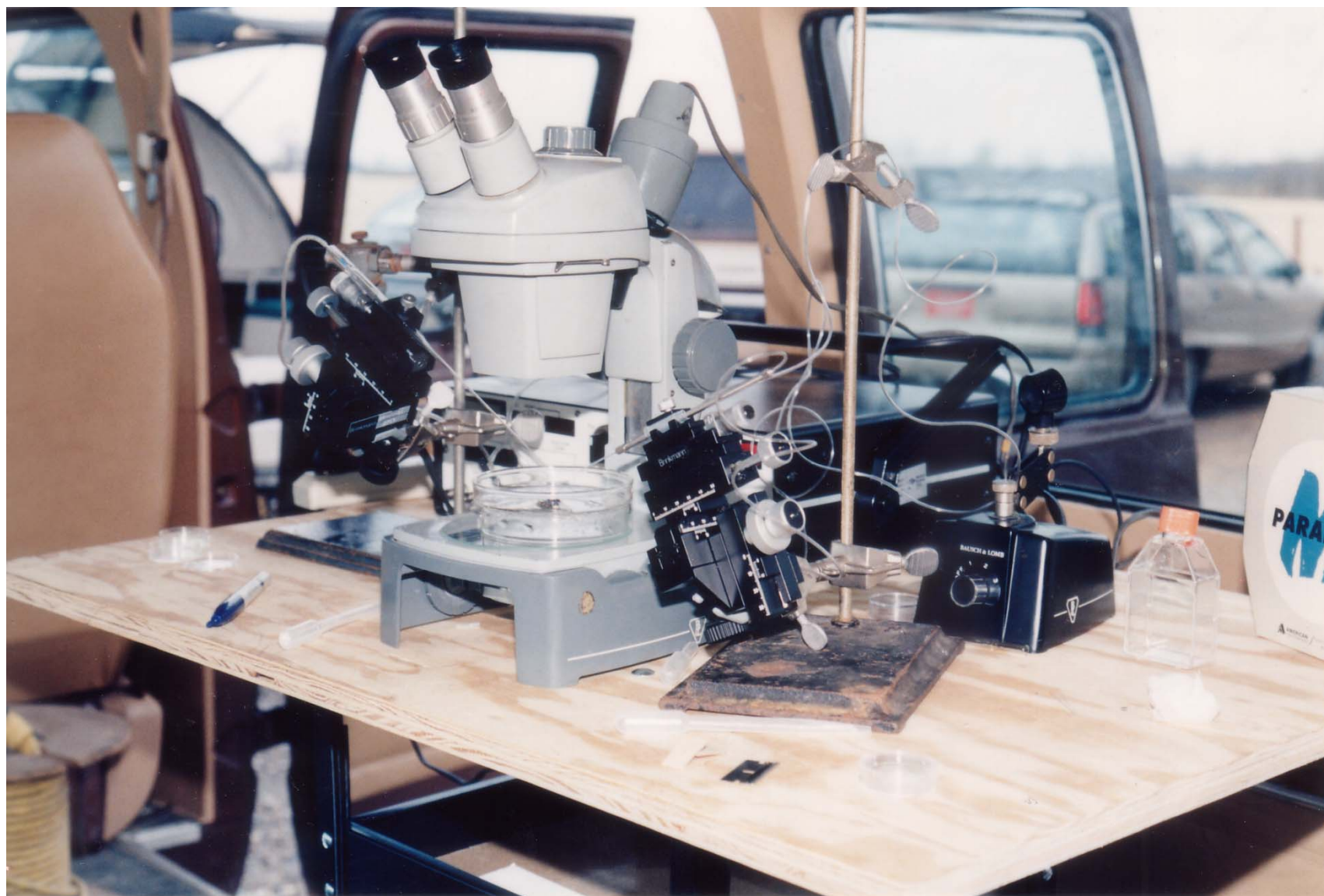


Jelly coat is being removed from the fertilized lake sturgeon eggs using bentonite. 1994. Fox River, Osh Kosh, Wisconsin, USA.

pSV40 β lacZnls12co Vector

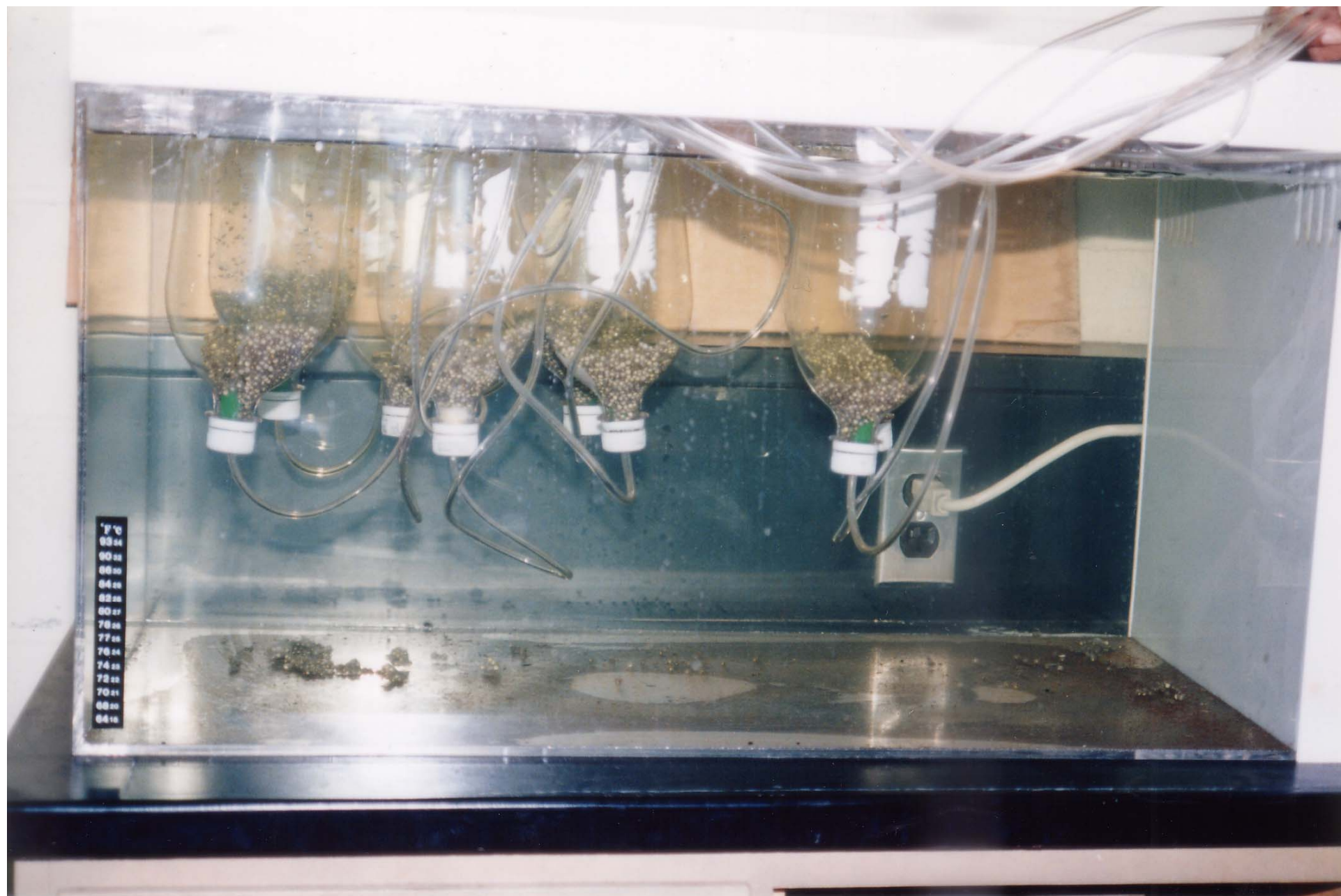
The *lacZ* gene with SV40 promoter was used to develop GI lake sturgeon

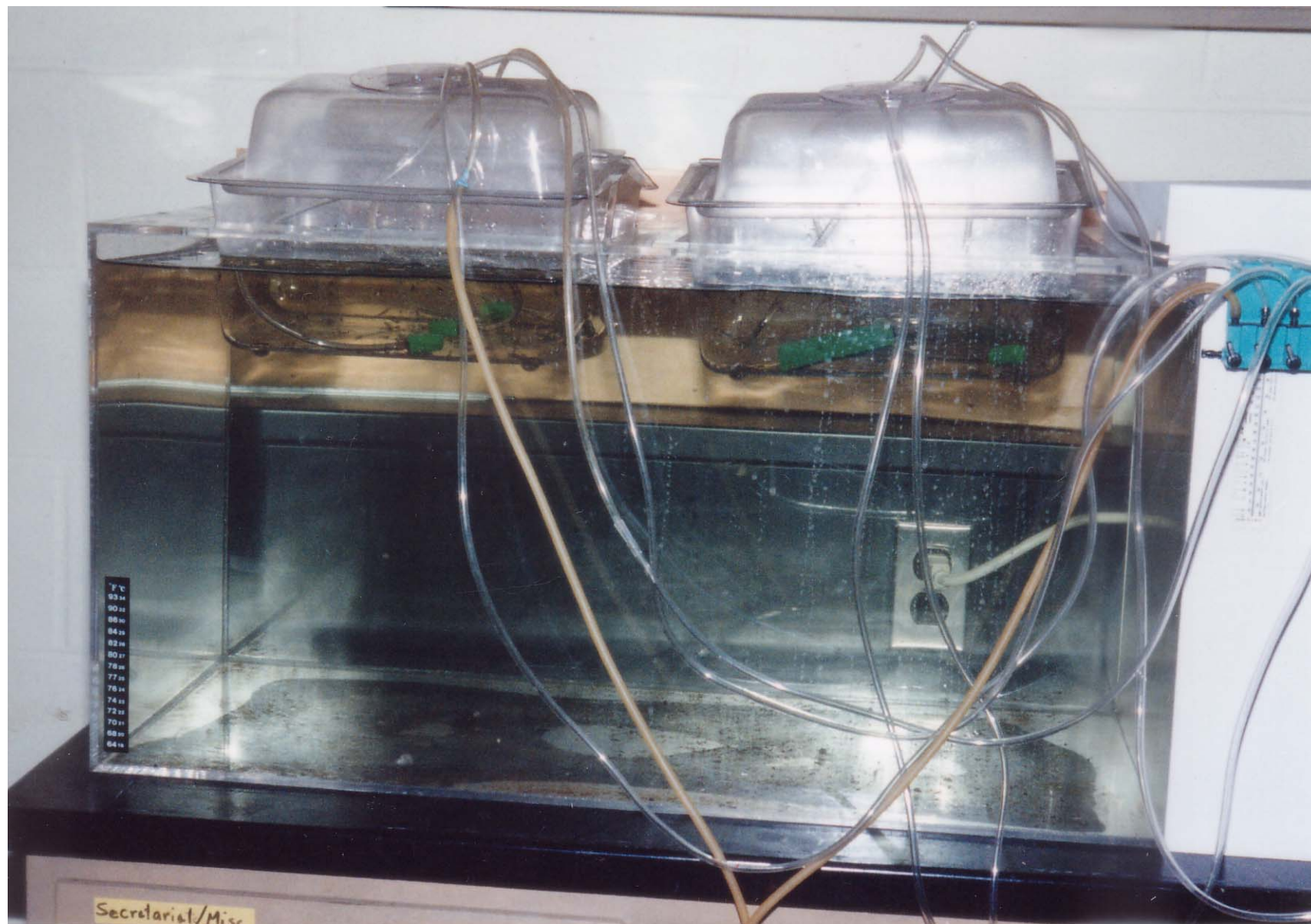


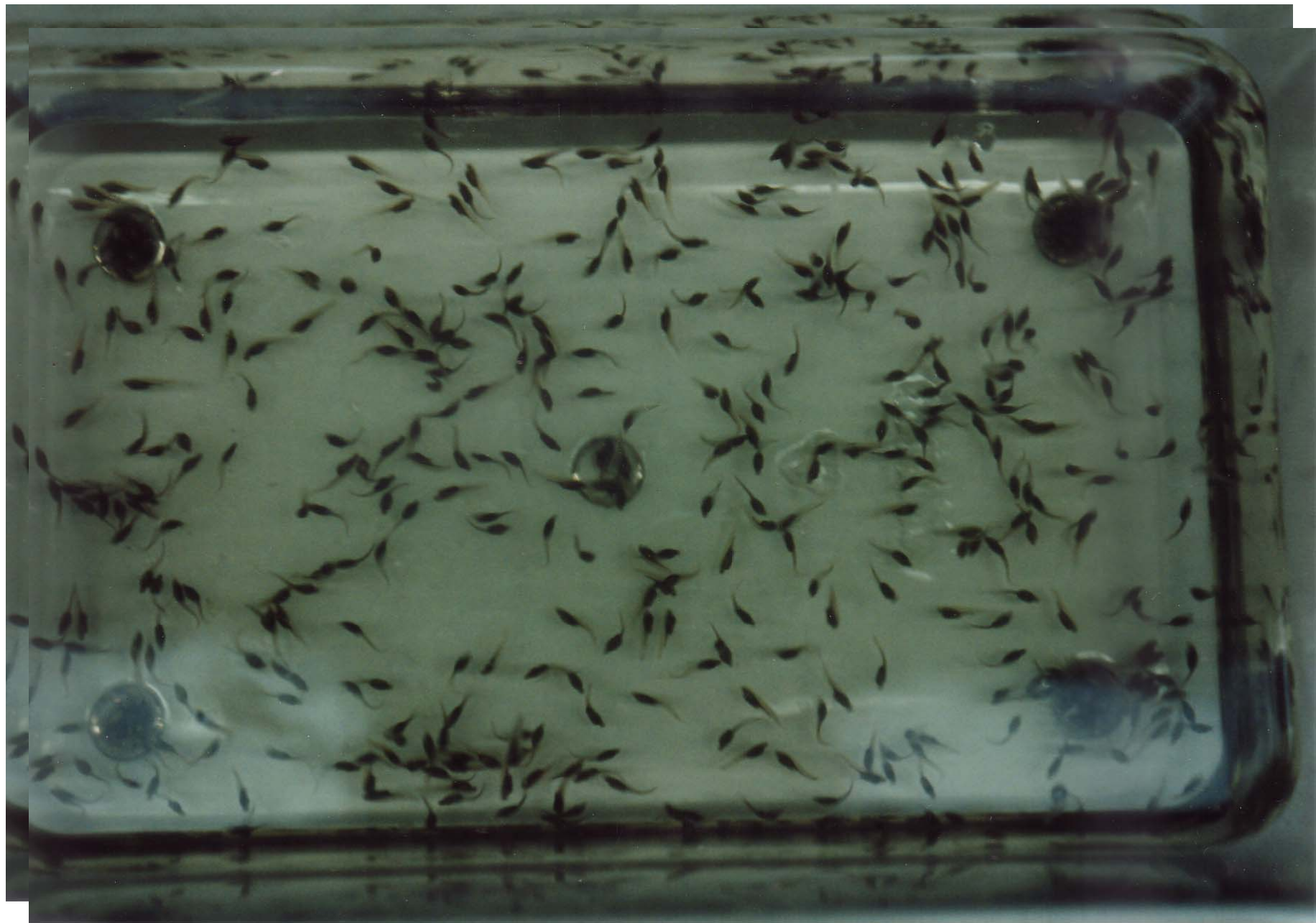




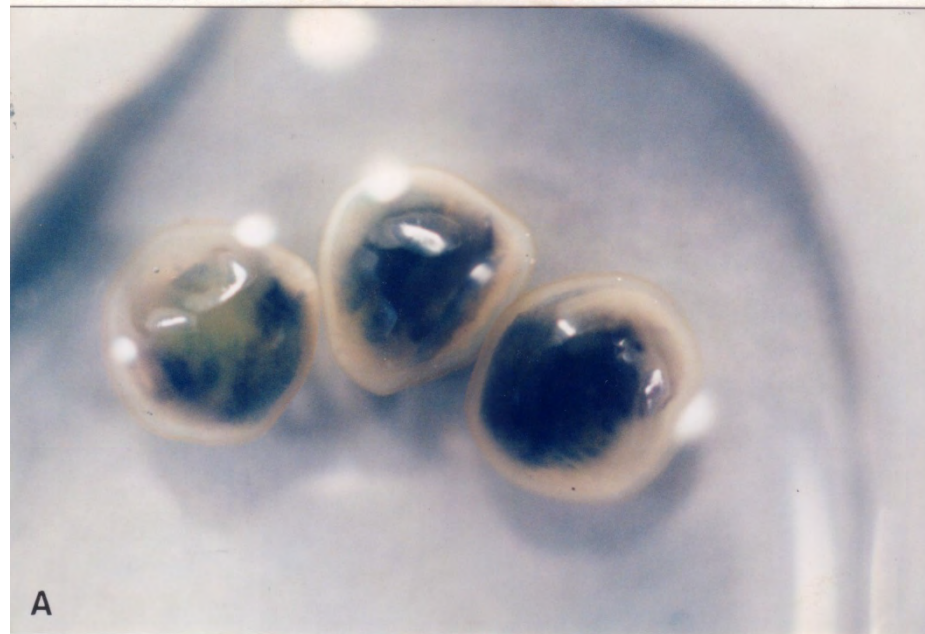




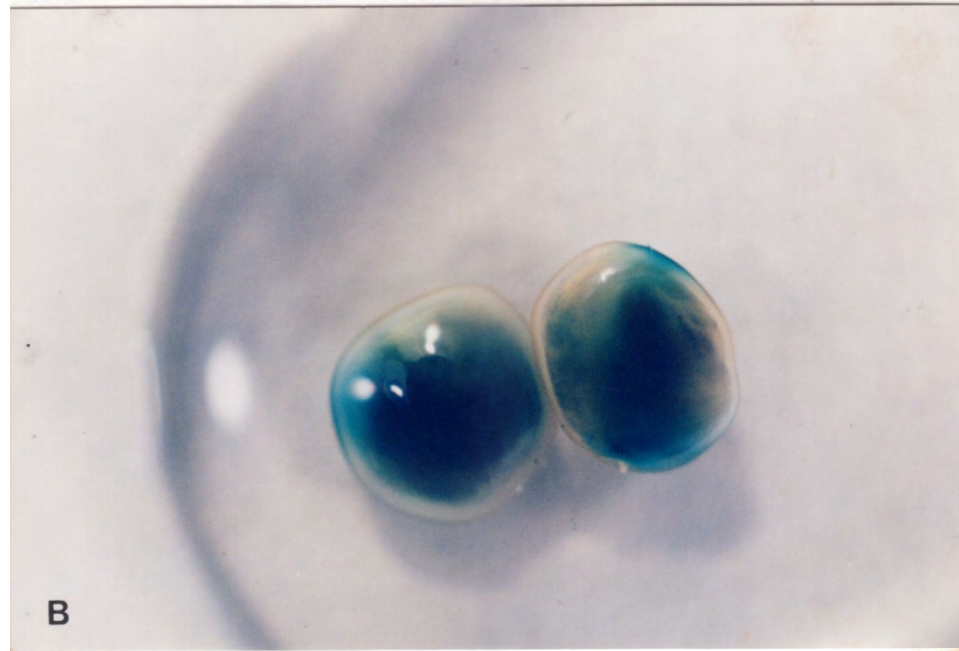




Control Embryos



Experimental Embryos



Control Larvae



Experimental Larvae





Six month old control lake sturgeons tested with X-Gal don't turn blue.



Six month old GM lake sturgeon tested with X-Gal turns blue.

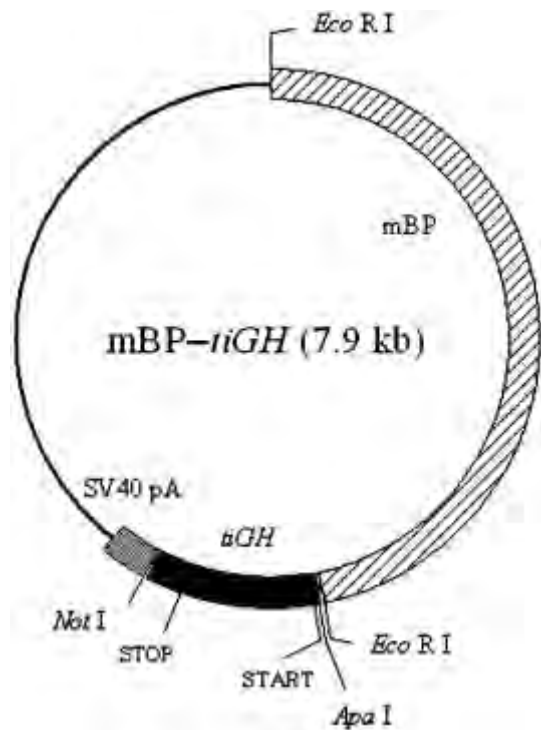
Tail Fins



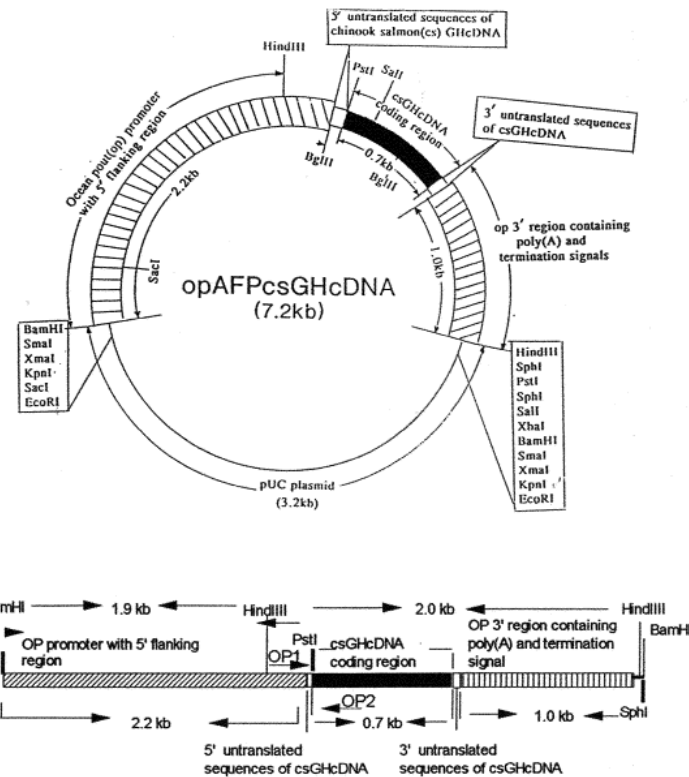
GI Tilapia Already Developed With Growth Hormone (GH) Gene

- **Several laboratories have already produced GI Tilapia with different GH genes.**
- **GH-GI Tilapia showed 3.6 X less food consumption.**
- **GH-GI Tilapia had 290% higher food conversion efficiency.**
- **GH-GI Tilapia with tilapia-GH gene grew 82% larger.**
- **GH-GI Tilapia with Chinook GH and Ocean pout AFP promoter grow 300% faster and to 5 X normal size.**
- **Other GH constructs are still possible to try especially with different control elements included.**

Growth Hormone Gene Constructs Used in GM Tilapia



Tilapia GH (tiGH) gene construct with SV40 pomoter.



Chinook GH (tiGH) gene construct with Ocean pout AFP pomoter.

ARE GM TILAPIA SAFE TO EAT?

- **In the USA, about 70% of all food eaten is GI**
- **Of grains, more than 90% is already GI**
- **The US FDA declared in its initial evaluation of AquaBounty salmon that it was: 1. safe as food, 2. safe to the fish, 3. safe for the environment**
- **Final FDA approval is expected soon**
- **But for the moment, GI fish should only be grown in closed waters until more information is forthcoming and their total safety proven**

Some Tilapia can have a high omega-6:omega-3 fatty acid ratio in comparison to 1:1 in salmons

- Diet can cause the higher ratios since Omega-3 is normally taken up from food sources**
- But a balance of both n-3 and n-6 fatty acids are necessary for good human nutrition**
- Levels of both types of fatty acids should be easy to modify using GI to achieve the best possible n-3:n-6 balance**

Increasing the Vitamin Content of Tilapia

- **Vitamins are synthesized by metabolic pathways in fish tissues, or by intestinal bacteria, or captured from food sources**
- **Using GI techniques, we can isolate the genes for vitamin biosynthesis either directly from fish or other sources or from bacterial cells**
- **We can also add control elements upstream from the genes and incorporate these constructs into Tilapia DNA**

Increasing Disease Resistance of Tilapia

- **Tilapia are known to become infected by a variety of bacteria, viruses, protozoans and some fungal agents.**
- **It should be possible using GI techniques to isolate the genes useful to combat infection by many of the above agents.**
- **And it may be possible also to increase the immunological response of Tilapia by GI.**

Summary

- The addition of GM techniques can vastly improve the productivity of Tilapia aquaculture and increase nutritional value
- The City University of New York is able to partner with any person or groups interested in pursuing GI techniques
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