Determining Significant Endpoints for Ecological Risk Analysis

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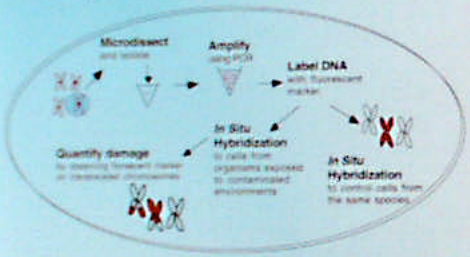
Molecular Probe

- We have developed, what is to our knowledge, the first chromosome-specific probe for a non-mammalian vertebrate
- The probe was made using microdissection and polymerase chain reaction amplification techniques
- Using fluorescent *in situ* hybridization (FISH), the probe measures cumulative damage in exposed individuals by quantifying a stable form of chromosome damage called reciprocal translocations

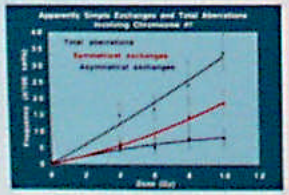


Reciprocal translocation in chromosome #1

The probe was developed for a common turtle species, the yellow-bellied slider.

- long-lived (30 y)
- found in numerous contaminated locations on DOE sites
- can accumulate an appreciable dose
- has a wide geographical range

- Both symmetrical and asymmetrical exchanges on the # 1 chromosome can be detected with the probe
- Frequencies of detected chromosomal exchanges are highly correlated with dose (R^2 > 0.95)



Because the same species do not occur at all DOE sites, we are encouraged that:

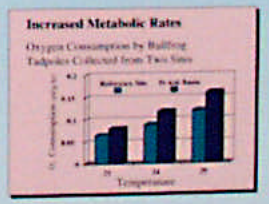
- **the probe may have wide applicability across numerous species**
  (It has worked in three genera of turtles within two different families, coded in red, and is being tested on two others, coded in blue)
- **it may also be a useful tool for comparative genomics**

For more information on this aspect of our work contact: Dr. Joel Bedford, Colorado State University, [illegible]

Metabolic Rate as an Indicator of Stress from Contaminant Exposure

- Metabolic rate measures an animal's cost of maintenance or activity
- Changes in metabolic rates have implications for processes such as energy storage, growth and reproduction
- Metabolic rate of exposed organisms:
  - may be an excellent physiological measure of sublethal stress because it reflects multiple processes occurring within an organism
  - may be a criterion for determining whether cellular effects from contaminant exposure are relevant to higher levels of biological organization

- We have documented increased metabolic rates in numerous species of animals exposed to nonradioactive contaminants from a coal ash basin



Currently we are testing:

- whether metabolic rates increase in animals exposed to chronic, low level radiation
- how changes in metabolic rates differ when organisms are exposed to both radioactive and non-radioactive contaminants
- how previous exposures to contaminants affect the metabolic response from subsequent exposures

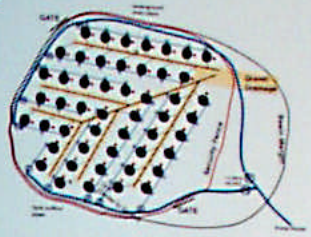
For more information on this aspect of our work contact: Dr. Justin Congdon, [illegible]

Irradiation - Mesocosm Facility

- Animals can be reared in 50 outdoor mesocosms designed to test effects of chronic, low level irradiation, alone and in conjunction with metal contaminants

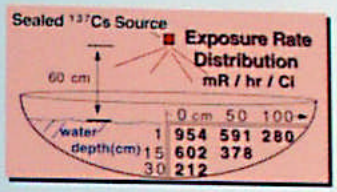
- Replicate treatments and powerful statistical methods are possible

- Each mesocosm has a sealed ^{137}Cs source located above it



Schematic of facility

- Radiation exposures to animals can be quantified using thermoluminescent dosimeters



- Using a variety of organisms we can determine:

1) the frequency of chromosome damage at various radiation exposures and metal contaminant concentrations

2) the relationship between cellular damage and metabolic rate

3) treatment effects on an individual's energy allocation pattern, growth and survival

Benefits to the DOE

- reduce uncertainties associated with ecological risk analyses
- provide defensible scientific evidence on which cleanup decisions can be based
- broad application across DOE sites
- reduce DOE's need to take an ultra-conservative approach to cleanup, resulting in substantial cost savings

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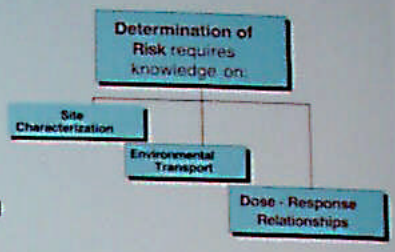
Introduction

- DOE faces complex decisions regarding clean-up of contaminated sites
- Science can enter the decision making process through human and ecological risk analyses
  - The science of quantifying risk to humans from exposure to radiation is well developed and internationally accepted
  - In contrast, the methods, endpoints and interpretation of ecological risk analyses are still being developed and lack standardization



Fundamental Differences In Human and Ecological Risk Analyses

Type	Unit of Observation	Endpoint	Dose-Response
Human	individual	lifetime cancer risk	relationships established
Ecological	varies	varies	not established

individuals, population, community, ecosystem, or ??

sublethal effects, < fecundity, > mortality or ??

for chronic, low level exposure to radiation, alone, or mixed with other contaminants

- DOE needs a scientifically defensible protocol for measuring ecological risks
- A sound protocol is possible only when the relationship between sublethal, cellular damage is made with the performance of individuals and populations exposed to:
  - chronic, low-level radiation, and
  - radiation in combination with chemical contaminants

Research Objective

- Establish protocols for assessing ecological risks by coupling molecular damage to effects observed at the individual and population levels of biological organization

Molecular Damage

leads to:

Changes in Metabolic Rate and Energy Allocation

leads to:

Changes in: Age-specific Survivorship, Reproductive Output, Age at Maturity, Longevity

Our Emphasis To Date Has Been:

1) developing a molecular probe (panel #2)
2) quantifying responses of organisms exposed to contaminants (panel #3)
3) constructing an irradiation - mesocosm facility (panel #4)