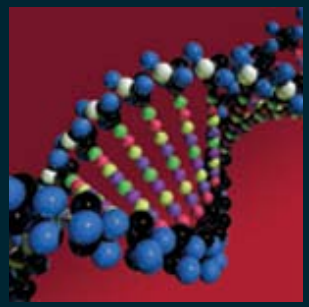
Assessing environmental damage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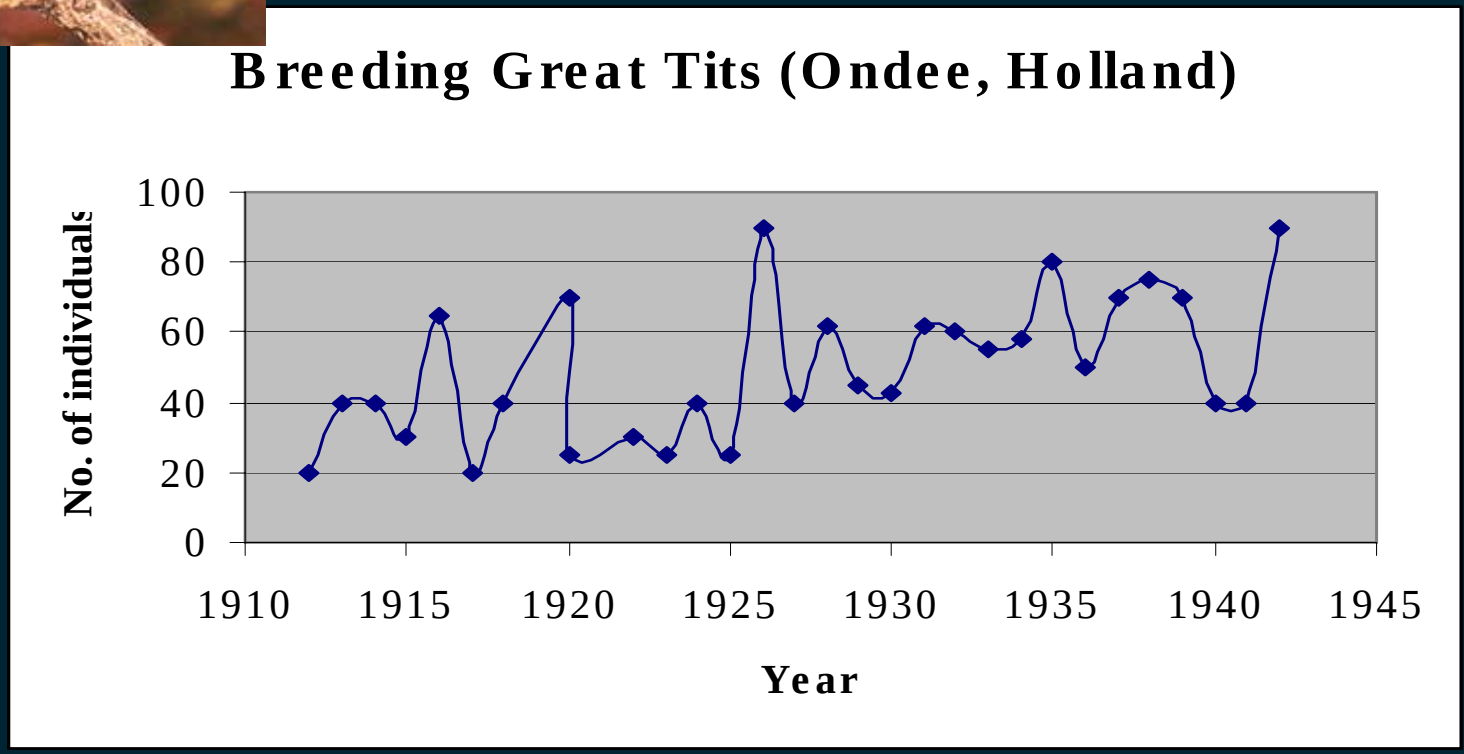
Agenda

- How do we make decisions on environmental damage?
  - Definitions and indicators for damage
  - Baseline conditions
  - Establishing causation
- What tools do we use?
  - Conceptual site models
  - Delineating the impacted area
  - Tools for measuring ‘adverse effect’
- What are the immediate and long-term actions?

Making decisions

What is damage?

The need to disentangle effects due to contamination from those arising from natural variation is central to damage assessment



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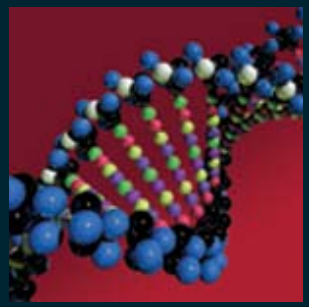
Definitions of damage


Definitions

Indicators of adverse effects

Definitions of damage

ELD and its transposition

ELD defines damage as, a measureable adverse change in a natural resource or measureable impairment of a natural resource service

The draft Regulations define damage as,

- within a SSSI, significant environmental damage to protected species, natural habitats and SSSIs is an adverse effect on the integrity of a site or,
- outside a SSSI, a significant adverse effect on the species or habitat reaching or maintaining their favourable conservation status in UK

Definitions of damage

Guidance for ‘site integrity effects’

“The coherence of its ecological structure and function, across its whole area, that enables it to sustain the habitat, complex of habitats or the levels of populations of the species affected”

- Guidance provides a series of prompts for judging damage
  - Requires an assessment of ecological structure and function

    i.e. measure BOTH
  - Focus on species or habitats

    i.e. measure one of these and assume “one out, all out” rule

Definitions of damage

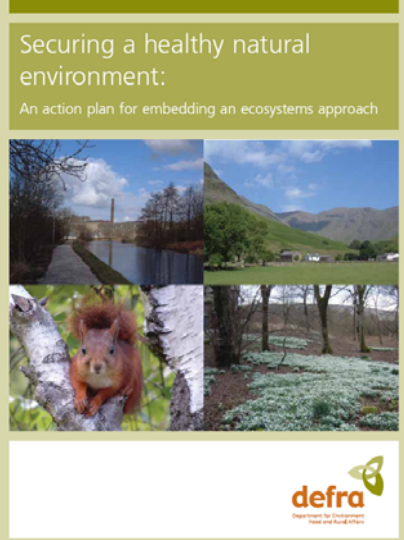
In Part 2A, Significant Harm is…

- “harm which results in an irreversible change, or in some other adverse change in the functioning of the ecological system within any substantial part of that location”.
- “harm which affects any species of special interest within that location and which endangers the long-term maintenance of the population of that species at that location”.
- “harm that is incompatible with the favourable conservation status of natural habitats at that location or species typically found there”.

Definitions of damage

Indicators of adverse effect

Indicators are measurable attributes



- Representative of ‘ecological services’
  - Structural parameters and functional parameters
- Adapt to spatial scales
- Sensitive to change
- Cost must not be prohibitive, esp. large scale assessment
- Practicality
  - unambiguous,
  - easy to measure, and
  - relevant data must be readily available

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Indicators of adverse effect

- Mortality (short-term endpoints)
- Reproduction, growth, development, activity, lesions, physiological changes, respiration, nutrient-cycling, contribution to decomposition, genetic adaptation, and physiological acclimatisation (long-term endpoints)

From Canadian Council of Ministers for the Environment, CCME

Indicators of adverse effect

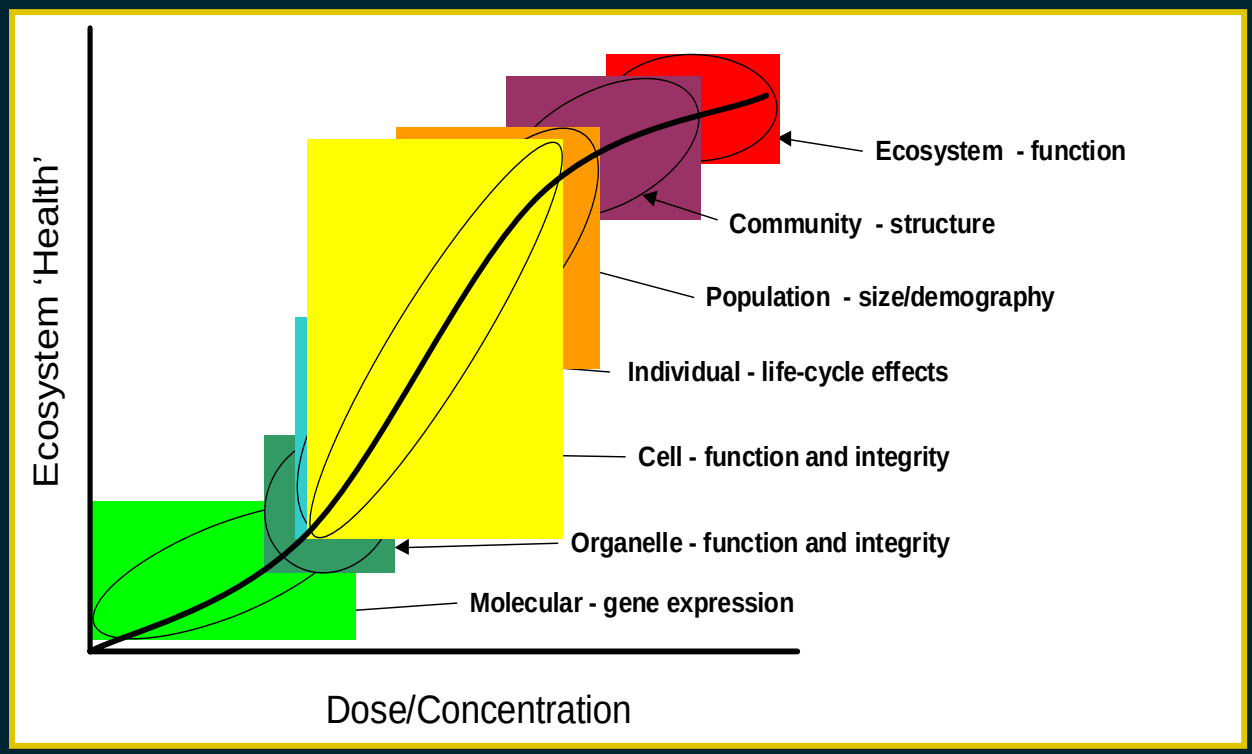
- Mortality
- Reproduction, growth

Ecologically relevant lifecycle parameters

Adverse effect is when growth, reproduction or mortality are adversely affected, such that the survival of the population/ community/ species is threatened

Definitions of damage

Tools for measuring indicators



- 5 R's
  - Responsive
  - Robust
  - Reproducible
  - Representative
  - Relevant
- & P
  - Practical

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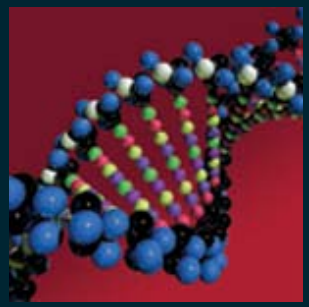
Making decisions on damage


Baseline condition

Causation

Making decisions

Baseline condition

… is the condition that would exist at the time of the damage to ecological services had the damage not occurred

- Must be accurate, as it will be used to determine the remediation goals
- Take account of physical, biological and chemical conditions
- Must be reasonable; ecosystem services approach allows for:
  - anthropogenic inputs
  - resource use/loss *e.g. harvesting of crops*

In decision-making

- Compare indicators of ‘adverse effect’ with a baseline condition
- Are they significantly different?
- Use trends in preference to a single point in time

Making decisions

Baseline condition

Methods for determining baseline conditions

- Reference sampling site
  - *up gradient, pre-release condition*
- Modelling (hind-casting)
- Re-constructing baseline from historic site information
- International, national, regional or local data
  - *maps and databases*
  - *conservation bodies, biological records centres*
  - *monitoring programmes, e.g. Countryside Survey 2007*

Causation

… are observed adverse effects due to the incident under investigation and therefore, are specific operators liable?

- Determining a causal link is key
- But, often difficult to determine

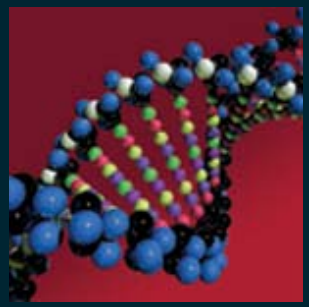
Making decisions

Causation

Establish a causal link between operator and environmental damage

- Measures of damage must be specific, or
- Use a range of assessment methods relevant to types of services and contamination
- Complexity of factors often requires a weight-of-evidence approach, e.g.
  - Chemical fingerprinting
  - Demonstrated stressor-response relationship
  - Ecological evidence (qualitative)
  - Biological plausibility (quantitative data from surrogates)

Tools for assessing damage

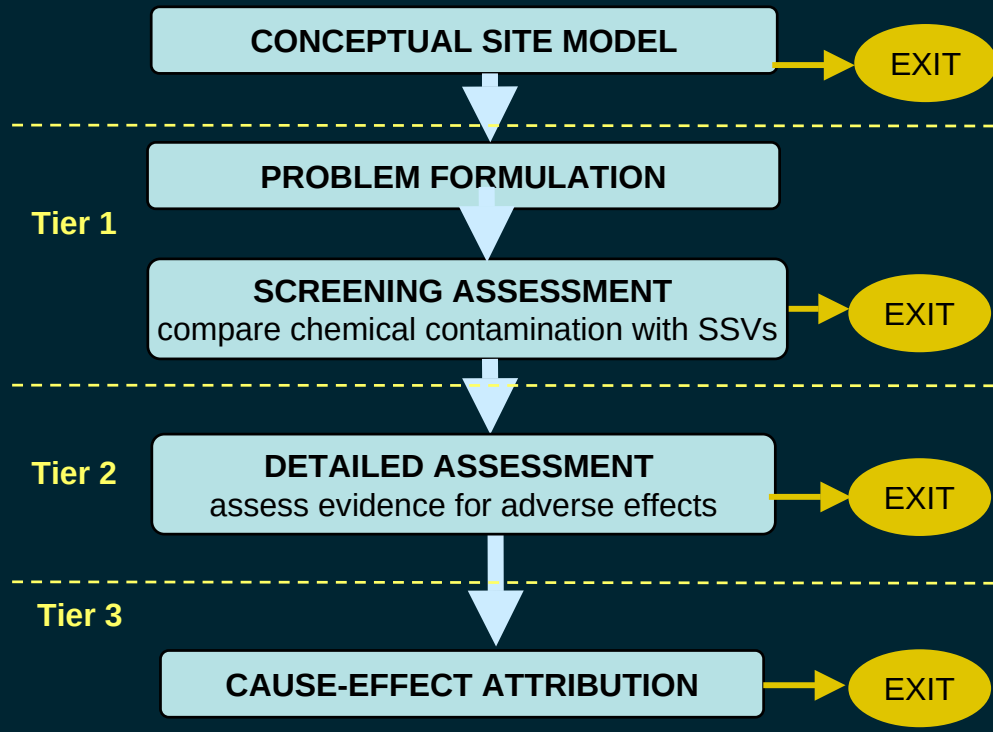

Conceptual site models

Delineating the impacted area

Tools for measuring ‘adverse effect’

Phased approach

- Screening assessment
  - Develop CSMs
  - Agree the aims, indicators and thresholds
  - Use screening tools to indicate plausibility
- Detailed assessment
  - Biological and ecological tools for assessing damage
  - Do observed effects correspond to source of contamination?



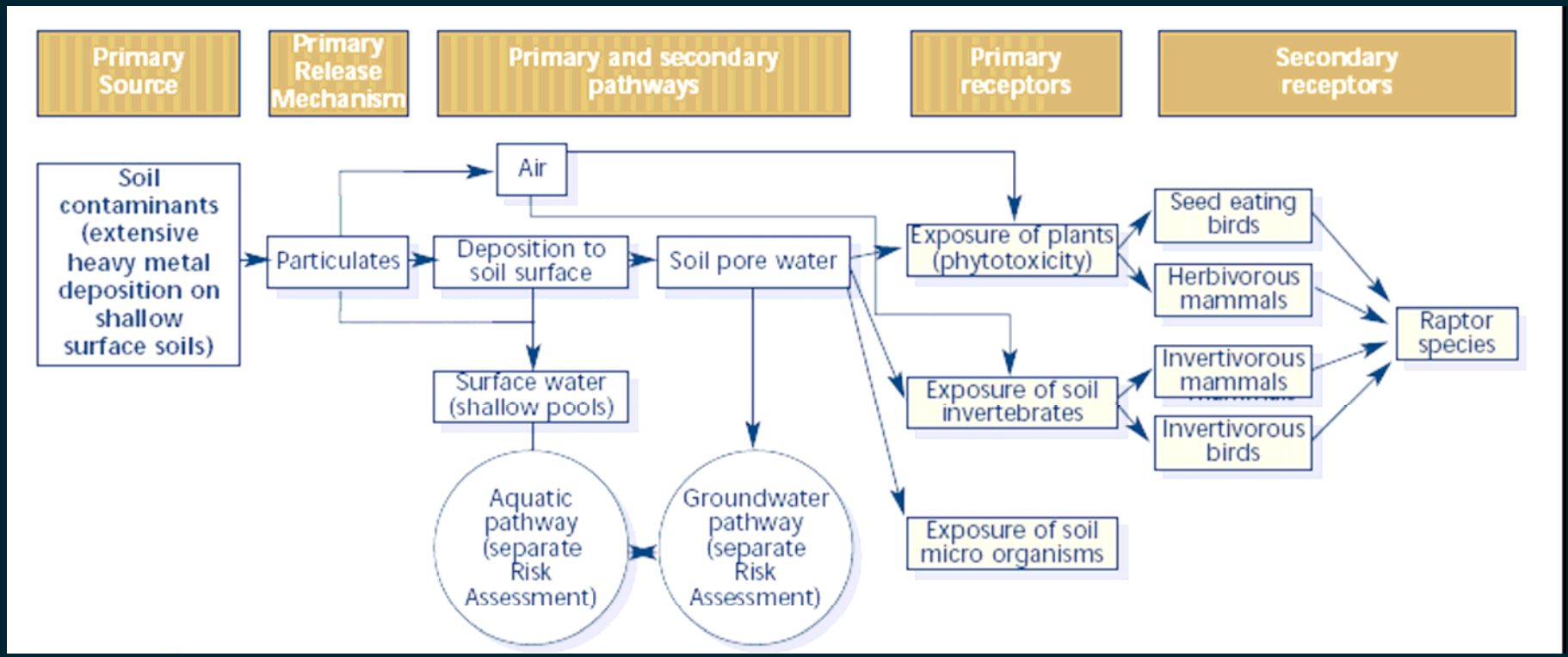
Tools for assessing damage

Conceptual site models

- Source
  - Site conditions *e.g. soil type*
  - Contaminant characteristics *e.g. concentration, breakdown*
- Pathway
  - Movement in environment *e.g. leaching, inhalation of airborne particles*
- Receptor
  - Identify ‘ecosystem services’ of concern
    - Provisioning service *e.g. food (prey), foraging habitat, shelter*
    - Supporting services *e.g. nutrient cycling*

Tools for assessing damage

Conceptual site models



Consider the CSM in the context of ‘ecological services’

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Tools for assessing damage

Framing the questions

- Define the assessment goals - focus only on the ecological services that are relevant and are affected
- Describe the indicators for these services and how they will be measured
- Agree thresholds for ‘adverse effects’
- Agree how effects will be attributed to causes

Framing the questions in an assessment

In risk assessment, this is Problem Formulation

- Assessment endpoints describe environmental attributes (conservation objectives for SSSI)
  - *e.g. entire UK population of a particular bird species*
- Measurement endpoints are quantifiable indicators or parameters of attributes
  - *e.g. number of offspring per female per year*
- Thresholds or criteria for ‘adverse effect’
  - *E.g. mean value of a indicator is significantly different (at 95% confidence level) from the mean reference or control value*

Tools for assessing damage

Delineating the impacted area

- Define the area
  - Geology (permeability)
  - Soil type (pH)
  - Depth to groundwater (relative to source datum)
  - Extent of contamination (thickness, width, flow direction)

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Tools for assessing damage

Chemical assessment

- Routine laboratory analyses
- Compare measured environmental concentrations against relevant screening values
  - *e.g. Environmental Quality Standards, soil screening values*
- Chemical fingerprinting
  - *e.g. detect differences in PAHs from a refined petroleum or a crude oil source*

Tools for assessing damage

Detailed assessment

- Dose-response data
  - species sensitivity distributions
- Body burdens
  - *e.g. chemical loading*
- Bioassays
  - assays that measure growth, reproduction, survival
  - functional assays such as litter decomposition
- Biomonitoring
  - Field studies detecting changes in lifecycle parameters
- Phase 1 and detailed ecological surveys
- Ecological models
  - *e.g. food chain effects*

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Tools for assessing damage

Determining ‘damage’

- Quantitative criteria for ‘adverse effect’
- Compare to baseline condition
- Attribute effects to cause

  For example, using Hill’s causal criteria such as s*trength of association, consistency of association*

Biological test	Patch 5	Patch 4	Patch 3	Patch 2	Patch 1
Microtox ™	●	●	●	●	●
Nitrogen mineralisation	●	●	●	●	●
Earthworm adult survival	●	●	●	●	●
Earthworm reproduction	●	●	●	●	●
Collembola survival and reproduction	●	●	●	●	●
Bait lamina	●	●	●	●	●
Plant growth - monocotyledon	●	●	●	●	●
Plant growth - dicotyledon	●	●	●	●	●
Earthworm lysosomal membrane stability	●	●	●	●	●
Genetic biomarker - metallothionein	●	●	●	●	●

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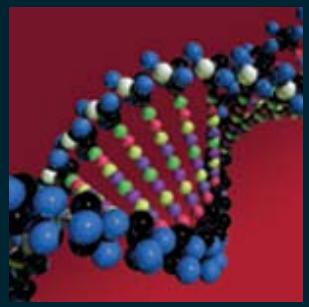
What are the immediate and long-term actions?


Actions and conclusions

Actions

Practicalities

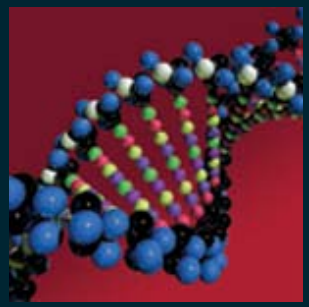
- Technical decisions are taken as part of a process
- Relevant parties meet at the start to agree indicators and thresholds
- Collect only the relevant data needed to answer the key questions
- Need inter-disciplinary teams

Actions

Conclusions

- Advise clients on imminent threat of damage by reviewing management systems
- Understand the baseline condition - don’t wait for an incident to happen!
- ELD transposition across Europe varies; implications for scope of damage and liabilities for multi-national businesses
- Where damage has occurred, use existing best practice including:
  - conceptualise the site
  - consider the wider context in terms of *ecological services*
  - define assessment objectives and criteria (quantitative, where possible)
  - select indicators for adverse effects
  - use appropriate baseline conditions
  - establish a causal link

Thank you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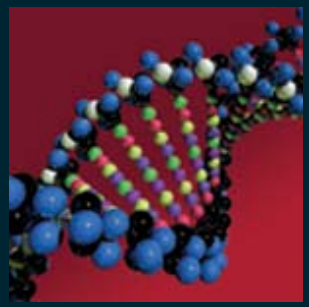


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