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The Known Distribution of Dragonflies and Damselflies in the State of Idaho

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Abstract

This "working document" is an attempt to bring together odonate collection and distribution information from two major sources, the Odonata Central database and *The Dragonflies (Odonata) of Idaho* (2011) on the Slater Museum of Natural History website, and to present it in a clear and easily-accessible form. The report actually contains neither any new data nor new collection records, but is an effort to consolidate information from various available sources into a concise and useful form. Every care has been taken to insure the accuracy of the information, and any errors, omissions, or oversights are the fault of the author. Perhaps the information presented here can serve as a convenient reference for additional collecting and studying of Idaho odonates.

Methodology

When beginning to compile the data for Idaho, I was thrilled to find Dennis Paulson's distribution/seasonality listing, *The Dragonflies (Odonata) of Idaho*, a great online resource which gave me a frame of reference for the Idaho fauna. In Idaho, a total of seventy-eight (78) species have been recorded—twenty-two (22) damselflies and fifty-six (56) dragonflies. (Paulson)

In the last few years, the advent of John Abbott's remarkable on-line Odonata Central (www.odonatacentral.org) has proven to be a valuable resource for listing individual collecting efforts, and documenting the presence of odonate species throughout the New World.

Information from Odonata Central for the selected counties was extracted first, with the submissions from Thomas W. Donnelly's Dot Map Project segregated from those entries representing collections by other individuals.

The author has presented the distribution data in several ways: first, by listing each species, showing first a distribution map, then a listing, of the counties from which the species has been reported. English names, as well as the taxonomic arrangement of the species accounts, are taken from Paulson & Dunkle.

This section is followed by a listing of the counties of the state, with a state map showing the location of the particular county, followed by a listing of the individual species which have been reported within each county.

THE COUNTIES OF IDAHO (44)

Ada	Cassia	Lewis
Adams	Clark	Lincoln
Bannock	Clearwater	Lake
Bear	Custer	Madison
Benewah	Elmore	Minidoka
Bingham	Franklin	Nez Perce
Blaine	Fremont	Oneida
Boise	Gem	Owyhee
Bonner	Gooding	Payette
Bonneville	Idaho	Power
Boundary	Jefferson	Shoshone
Butte	Jerome	Teton
Camas	Kootenai	Twin Falls
Canyon	Latah	Valley
Caribou	Lemhi	Washington

Summary

Every effort has been made to ensure the accuracy of this information. Any erroneous or incomplete data is the fault of the author. All suggestions, comments, or corrections are welcomed, and should be directed to:

George G. Sims
799 Vance Drive
Lander, Wyoming 82520-3519
georgesims@hotmail.com

THE SPECIES DISTRIBUTIONS

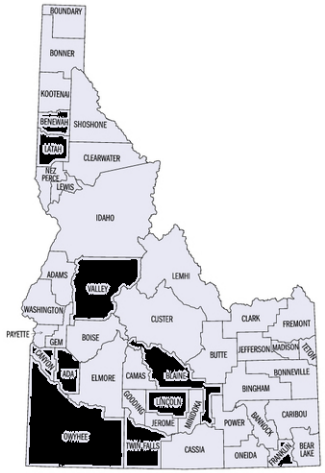
Suborder

ZYGOPTERA
Damselflies

CALOPTERYGIDAE
Broad-winged Damsels

***Calopteryx* Leach**
Jewelwings

Calopteryx aequabilis
River jewelwing



Ada
Benewah
Blaine
Canyon
Franklin
Latah
Lincoln
Owyhee
Twin Falls
Valley

LESTIDAE
Spreadwings

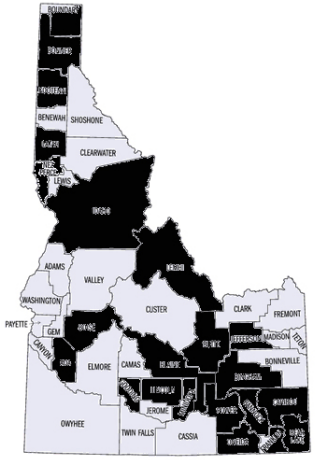
***Archilestes* Selys**
Stream Spreadwings

Archilestes californicus
California spreadwing

Latah
Nez Perce

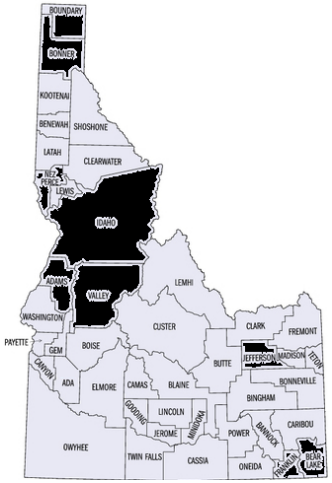
Lestes Leach
Pond Spreadwings

Lestes congener
Spotted spreadwing



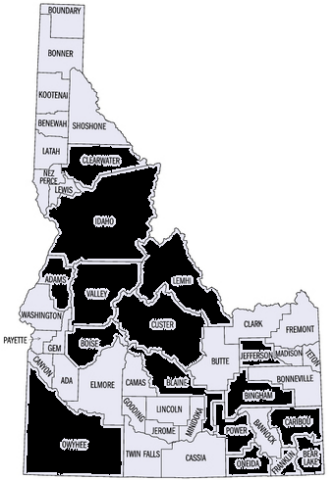
Ada
Bannock
Bear Lake
Bingham
Blaine
Boise
Bonner
Boundary
Butte
Caribou
Cassia
Franklin
Gooding
Idaho
Jefferson
Kootenai
Latah
Lemhi
Lincoln
Madison
Minidoka
Nez Perce
Oneida
Power

Lestes disjunctus
Northern spreadwing



Adams
Bear Lake
Bonner
Boundary
Franklin
Idaho
Jefferson
Nez Perce
Valley

Lestes dryas
Emerald spreadwing

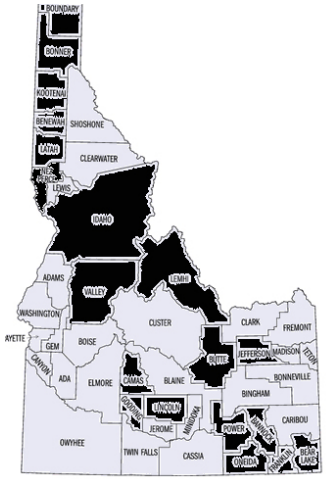


Adams
Bear Lake
Bingham
Blaine
Boise
Caribou
Clearwater
Custer
Franklin
Idaho
Jefferson
Lemhi
Oneida
Owyhee
Power
Valley

Lestes forcipatus
Sweetflag spreadwing

Boundary

Lestes unguiculatus
Lyre-tipped spreadwing

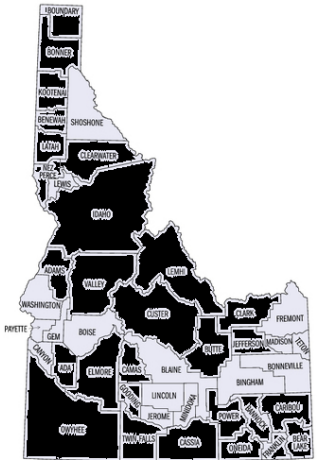


Bannock
Bear Lake
Benewah
Bonner
Boundary
Butte
Camas
Franklin
Gooding
Idaho
Jefferson
Kootenai
Latah
Lemhi
Lincoln
Nez Perce
Oneida
Power
Valley

COENAGRIONIDAE
Pond Damsels

***Amphiagrion* Selys**
Red Damsels

Amphiagrion abbreviatum
Western red damsel



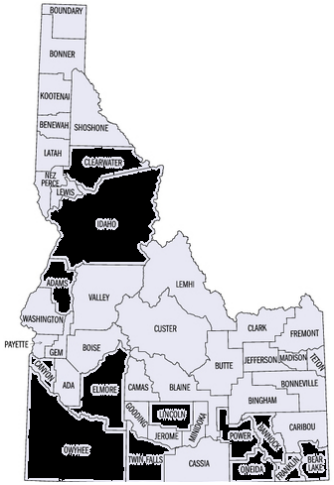
Ada
Adams
Bannock
Bear Lake
Benewah
Bonner
Boundary
Butte
Camas
Caribou
Cassia
Clark
Clearwater
Custer
Elmore
Franklin
Gooding
Idaho
Jefferson
Kootenai
Latah
Lemhi
Nez Perce
Oneida
Owyhee
Power
Twin Falls
Valley

Argia Rambur
Dancers

Argia alberta
Paiute dancer

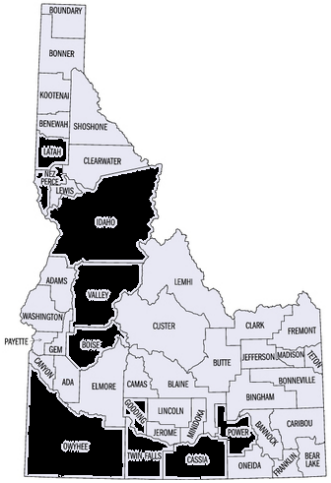
Clark
Owyhee
Power

Argia emma
Emma's dancer



Adams
Bannock
Bear Lake
Canyon
Clearwater
Elmore
Franklin
Idaho
Lincoln
Oneida
Owyhee
Power
Twin Falls

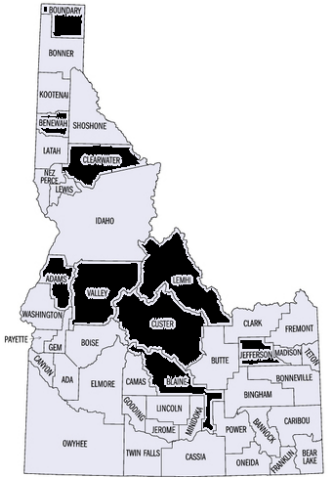
Argia vivida
Vivid dancer



Boise
Cassia
Gooding
Idaho
Latah
Nez Perce
Owyhee
Power
Twin Falls
Valley

Coenagrion Kirby
Eurasian Bluets

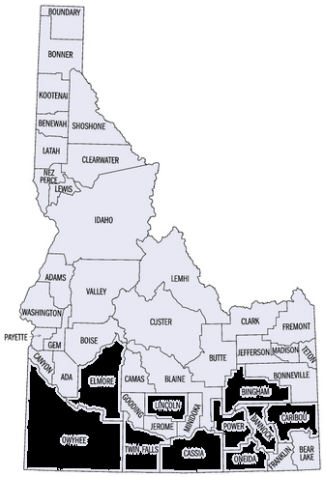
Coenagrion resolutum
Taiga bluet



Adams
Benewah
Blaine
Boundary
Clearwater
Custer
Jefferson
Lemhi
Valley

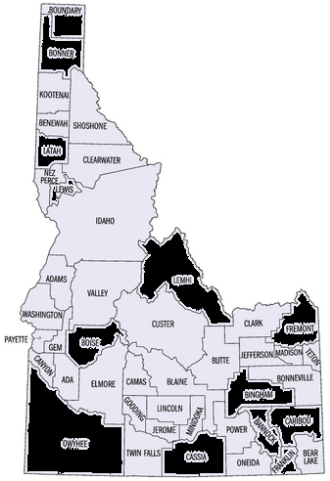
Enallagma Charpentier
American Bluets

Enallagma anna
River bluet



Bannock
Bingham
Caribou
Cassia
Elmore
Lincoln
Oneida
Owyhee
Power
Twin Falls

Enallagma annexum
Northern bluet



Bannock
Bingham
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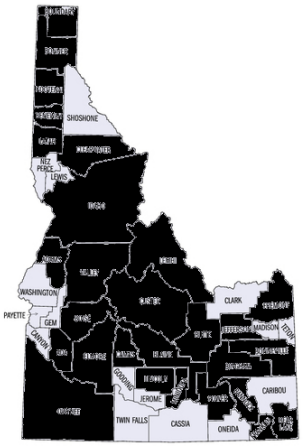
Bonner
Boundary
Caribou
Cassia
Franklin
Fremont
Latah
Lemhi
Lewis
Owyhee

Enallagma boreale
Boreal bluet



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Camas
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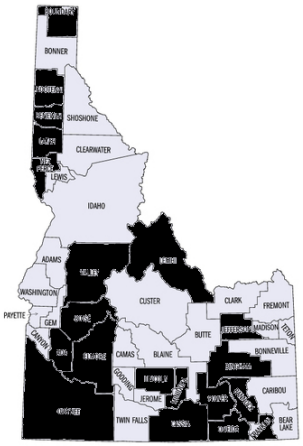
Custer
Elmore
Franklin
Fremont
Idaho
Jefferson
Kootenai
Latah
Lemhi
Lewis
Lincoln
Minidoka
Owyhee
Power
Valley

Enallagma carunculatum
Tule bluet



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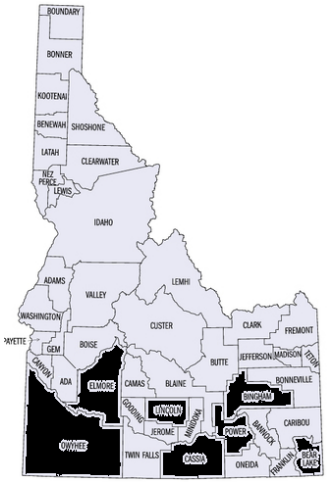
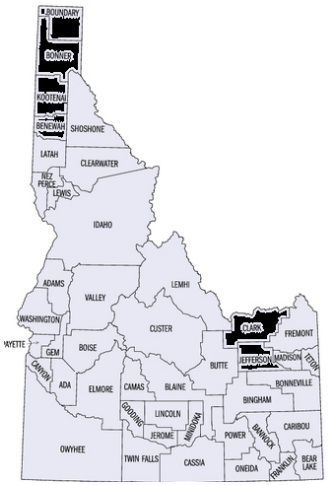
Cassia
Elmore
Franklin
Jefferson
Kootenai
Latah
Lemhi
Lincoln
Minidoka
Nez Perce
Oneida
Owyhee
Power
Valley

Enallagma clausum
Alkali bluet



Bear Lake
Bingham
Cassia
Elmore
Lincoln
Owyhee
Power

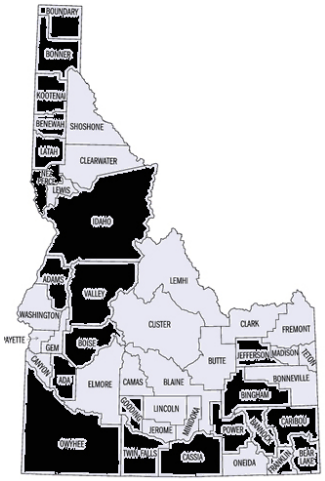
Enallagma ebrium
Marsh bluet



Benewah
Bonner
Boundary
Clark
Jefferson
Kootenai

Ischnura Charpentier
Forktails

Ischnura cervula
Pacific forktail



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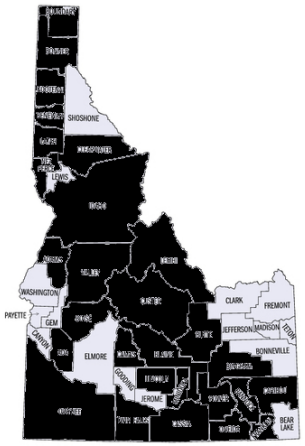
Bear Lake
Benewah
Bingham
Boise
Bonner
Boundary
Caribou
Cassia
Franklin
Gooding
Idaho
Jefferson
Kootenai
Latah
Nez Perce
Owyhee
Power
Twin Falls
Valley

Ischnura denticollis
Black-fronted forktail

Owyhee

Ischnura perparva
Western forktail



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Adams
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Bingham
Blaine
Boise
Bonner
Boundary
Butte
Camas
Caribou
Cassia
Clearwater
Custer
Franklin
Idaho
Kootenai
Latah
Lemhi
Lincoln
Minidoka
Nez Perce
Oneida
Owyhee
Power
Twin Falls
Valley

Nehalennia Selys
Sprites

Nehalennia irene
Sedge sprite

Boundary

SUBORDER

ANISOPTERA
Dragonflies

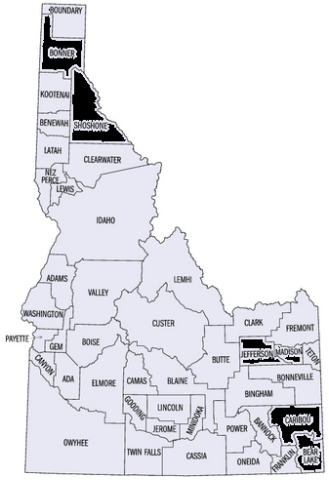
AESHNIDAE
Darners

Aeshna Fabricius
Mosaic Darners

Aeshna canadensis
Canada darner

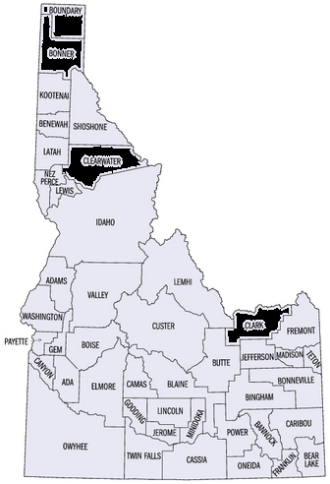
Bonner
Boundary

Aeshna constricta
Lance-tipped darner



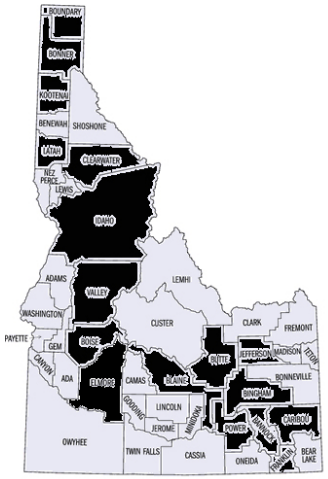
Bear Lake
Bonner
Caribou
Jefferson
Madison
Shoshone

Aeshna eremita
Lake darner



Bonner
Boundary
Clark
Clearwater

Aeshna interrupta
Variable darner

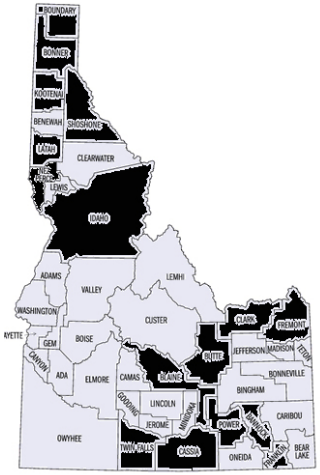


Bannock
Bingham
Blaine
Boise
Bonner
Boundary
Butte
Caribou
Clearwater
Elmore
Franklin
Idaho
Jefferson
Kootenai
Latah
Power
Valley

Aeshna juncea
Sedge darner

Boundary

Aeshna palmata
Paddle-tailed darner



Bannock
Blaine
Bonner
Boundary
Butte
Cassia
Clark
Franklin
Fremont
Idaho
Kootenai
Latah
Power
Shoshone
Twin Falls

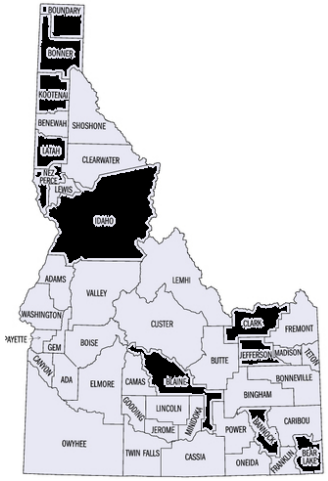
Aeshna sitchensis
Zigzag darner

Bonner
Custer
Oneida

Aeshna tuberculifera
Black-tipped darner

Bonner

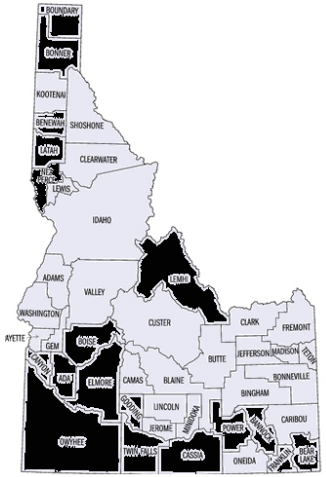
Aeshna umbrosa
Shadow darner



Bannock
Bear Lake
Blaine
Bonner
Boundary
Clark
Idaho
Jefferson
Kootenai
Latah
Nez Perce

Anax Leach
Green Darners

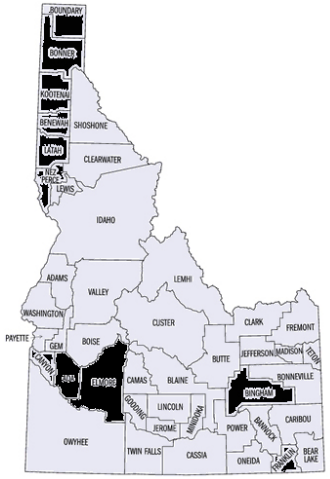
Anax junius
Common green darner



Ada
Bannock
Bear Lake
Benewah
Boise
Bonner
Boundary
Canyon
Cassia
Elmore
Franklin
Gooding
Latah
Lemhi
Nez Perce
Owyhee
Power
Twin Falls

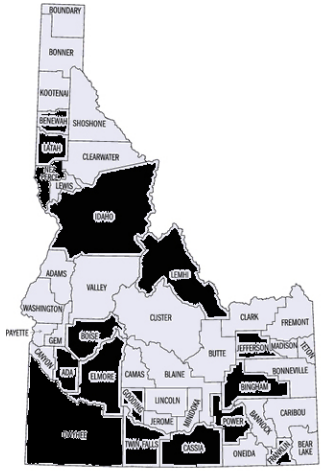
Rhionaeschna Förster
Neotropical Darners

Rhionaeschna californica
California darner



Ada
Benewah
Bingham
Bonner
Boundary
Canyon
Elmore
Franklin
Kootenai
Latah
Nez Perce

Rhionaeschna multicolor
Blue-eyed darner



Ada
Benewah
Bingham
Boise
Cassia
Elmore
Franklin
Gooding
Idaho
Jefferson
Latah
Lemhi
Nez Perce
Owyhee
Power
Twin Falls

GOMPHIDAE
Clubtails

Erpetogomphus Selys
Ringtails

Erpetogomphus compositus
White-belted ringtail

Owyhee

Gomphus Leach
Common Clubtails

Gomphus externus
Plains clubtail

Bannock
Franklin
Oneida

Gomphus graslinellus
Pronghorn clubtail

Bonner

Gomphus kurilis
Pacific clubtail

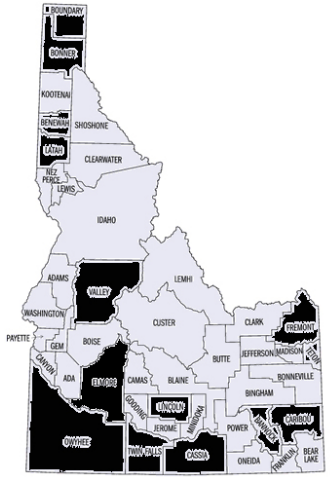
Valley

Ophiogomphus Selys
Snaketails

Ophiogomphus occidentis
Sinuous snaketail

Canyon
Nez Perce

Ophiogomphus severus
Pale snaketail



Bannock
Benewah
Bonner
Boundary
Caribou
Cassia
Elmore
Fremont
Latah
Lincoln
Owyhee
Teton
Twin Falls
Valley

Progomphus Selys
Sanddragons

Progomphus borealis
Gray sanddragon

Owyhee

Stylurus Needham
Hanging Clubtails

Stylurus olivaceus
Olive clubtail

Cassia
Franklin
Nez Perce
Power

CORDULIIDAE
Emeralds

Cordulegaster Leach
Spiketails

Cordulegaster dorsalis
Pacific spiketail

Cassia

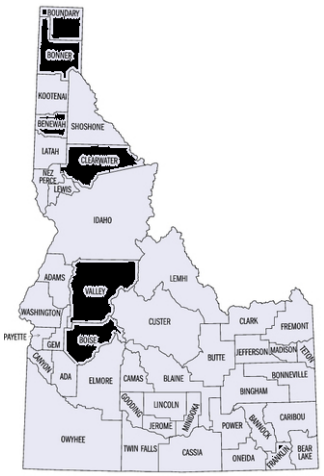
Macromia Rambur
River Cruisers

Macromia magnifica
Western river cruiser

Owyhee

Cordulia Leach
Common Emeralds

Cordulia shurtleffi
American emerald



Benewah
Boise
Bonner
Boundary
Clearwater
Valley

Epitheca Burmeister
Baskettails

Epitheca spinigera
Spiny baskettail

Benewah
Bonner
Boundary

Somatochlora Selys
Striped Emeralds

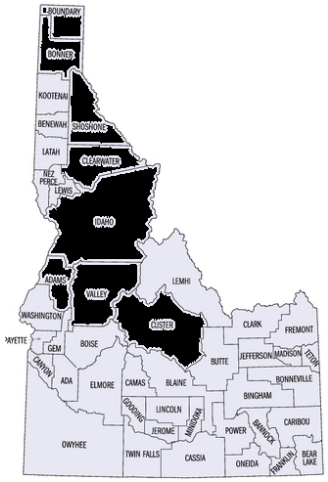
Somatochlora albicincta
White-ringed emerald

Boundary
Clearwater

Somatochlora minor
Ocellated emerald

Clearwater
Idaho
Latah

Somatochlora semicircularis
Mountain emerald



Adams
Bonner
Boundary
Clearwater
Custer
Idaho
Shoshone
Valley

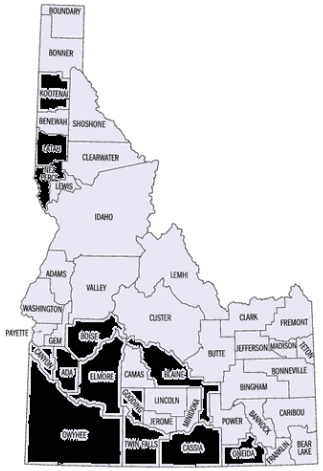
Somatochlora walshii
Brush-tipped emerald

Bonner

LIBELLULIDAE
Skimmers

Erythemis Hagen
Pondhawks

Erythemis collocata
Western pondhawk



Ada
Bannock
Blaine
Boise
Canyon
Cassia
Elmore
Gooding
Kootenai
Nez Perce
Oneida
Owyhee
Twin Falls

Ladona Needham
Corporals

Ladona julia
Chalk-fronted corporal

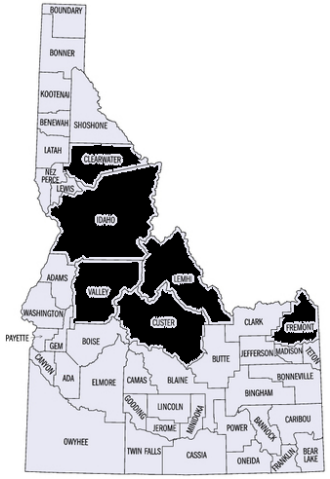
Bonner
Boundary
Idaho

Leucorrhinia Brittinger
Whitefaces

Leucorrhinia glacialis
Crimson-ringed whiteface

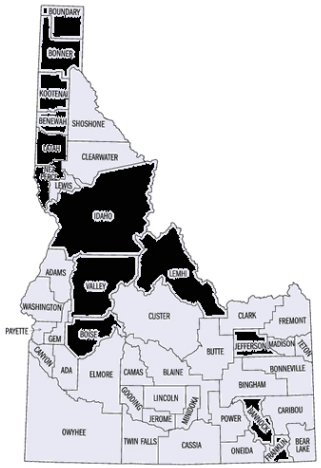
Clearwater

Leucorrhinia hudsonica
Hudsonian whiteface



Clearwater
Custer
Fremont
Idaho
Lemhi
Valley

Leucorrhinia intacta
Dot-tailed whiteface



Bannock
Benewah
Boise
Bonner
Boundary
Franklin
Idaho
Jefferson
Kootenai
Lemhi
Valley

Leucorrhinia proxima
Belted whiteface

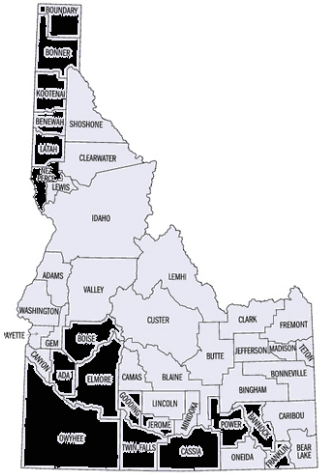
Bonner
Boundary
Lemhi

Libellula Linnaeus
King Skimmers

Libellula comanche
Comanche skimmer

Blaine
Owyhee

Libellula forensis
Eight-spotted skimmer

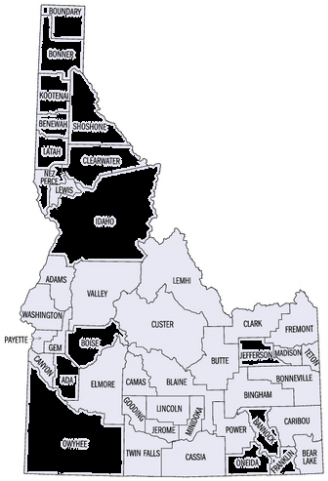


Ada
Bannock
Benewah
Bonner
Boundary
Boise
Cassia
Elmore
Franklin
Gooding
Jerome
Kootenai
Latah
Nez Perce
Owyhee
Power
Twin Falls

Libellula nodistica
Hoary skimmer

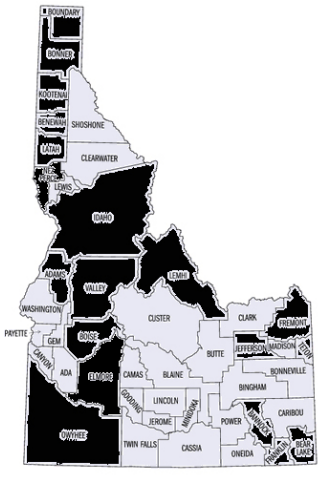
Owyhee

Libellula pulchella
Twelve-spotted skimmer



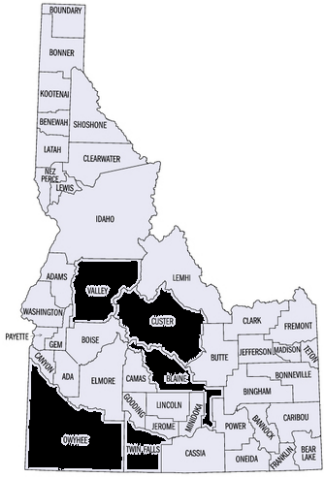
Ada
Bannock
Benewah
Boise
Bonner
Boundary
Clearwater
Franklin
Idaho
Jefferson
Kootenai
Latah
Nez Perce
Oneida
Owyhee
Shoshone

Libellula quadrimaculata
Four-spotted skimmer



Adams
Bannock
Bear Lake
Benewah
Boise
Bonner
Boundary
Elmore
Franklin
Fremont
Idaho
Jefferson
Kootenai
Latah
Lemhi
Nez Perce
Owyhee
Teton
Valley

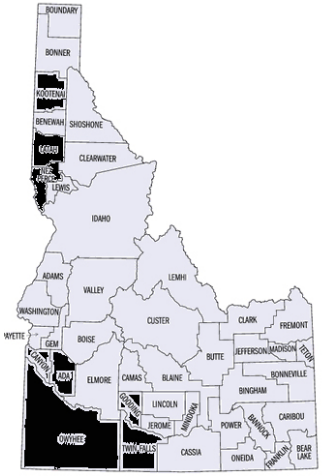
Libellula saturata
Flame skimmer



Blaine
Custer
Owyhee
Twin Falls
Valley

Pachydiplax Brauer
Blue dasher

Pachydiplax longipennis
Blue dasher



Ada
Canyon
Gooding
Kootenai
Latah
Nez Perce
Owyhee
Twin Falls

Pantala Hagen
Rainpool gliders

Pantala flavescens
Wandering glider

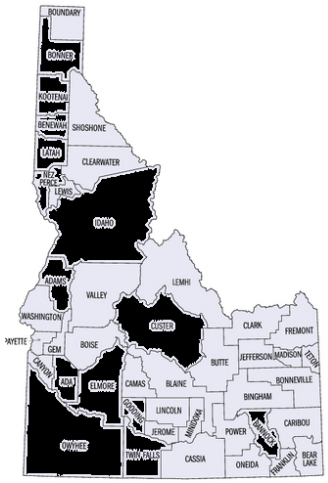
Elmore
Power
Twin Falls

Pantala hymenaea
Spot-winged glider

Gooding

Plathemis Hagen
Whitetails

Plathemis lydia
Common whitetail



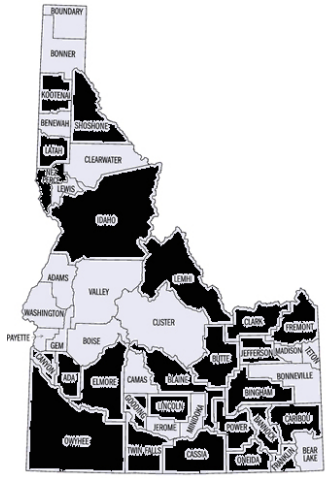
Ada
Adams
Bannock
Benewah
Bonner
Custer
Elmore
Gooding
Idaho
Kootenai
Latah
Nez Perce
Owyhee
Twin Falls

Plathemis subornata
Desert whitetail

Owyhee

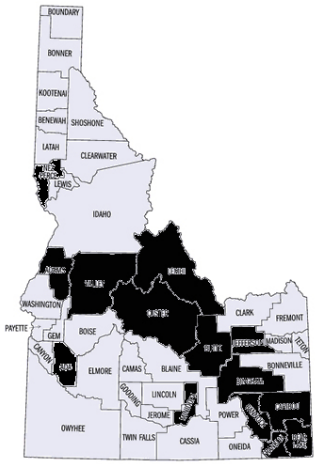
Sympetrum Newman
Meadowhawks

Sympetrum corruptum
Variegated meadowhawk



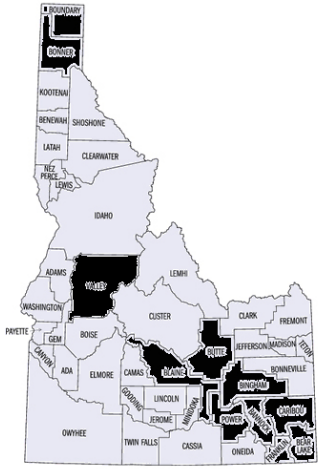
Ada
Bannock
Bingham
Blaine
Butte
Canyon
Caribou
Cassia
Clark
Elmore
Franklin
Fremont
Gooding
Idaho
Jefferson
Kootenai
Latah
Lemhi
Lincoln
Nez Perce
Oneida
Owyhee
Power
Shoshone
Twin Falls

Sympetrum costiferum
Saffron-winged meadowhawk



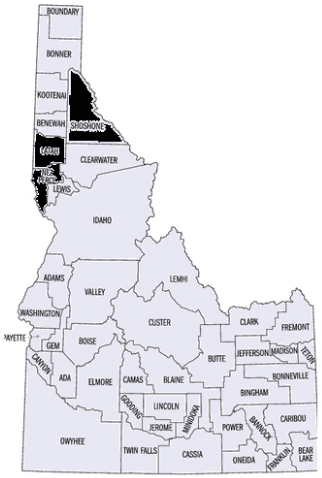
Ada
Adams
Bannock
Bear Lake
Bingham
Boundary
Butte
Caribou
Custer
Franklin
Jefferson
Lemhi
Nez Perce
Valley

Sympetrum danae
Black meadowhawk



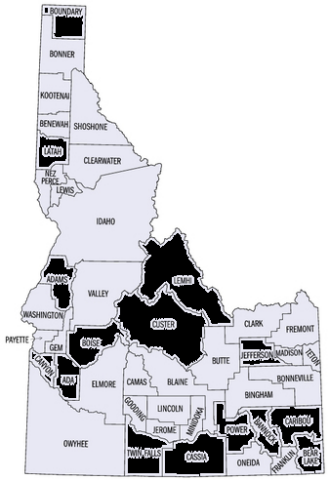
Bannock
Bear Lake
Bingham
Blaine
Bonner
Boundary
Butte
Caribou
Franklin
Power
Valley

Sympetrum illotum
Cardinal meadowhawk



Latah
Nez Perce
Shoshone

Sympetrum internum
Cherry-faced meadowhawk

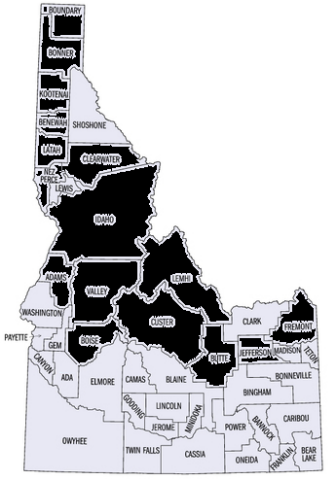


Ada
Adams
Bannock
Bear Lake
Boise
Boundary
Canyon
Caribou
Cassia
Custer
Jefferson
Latah
Lemhi
Power
Twin Falls

Sympetrum madidum
Red-veined meadowhawk

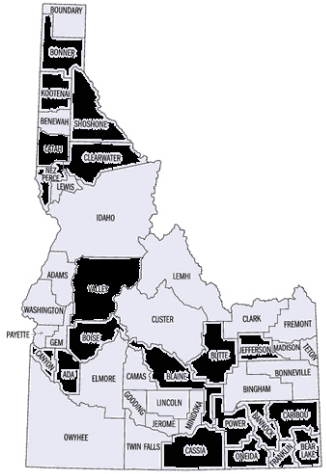
Power

Sympetrum obtrusum
White-faced meadowhawk



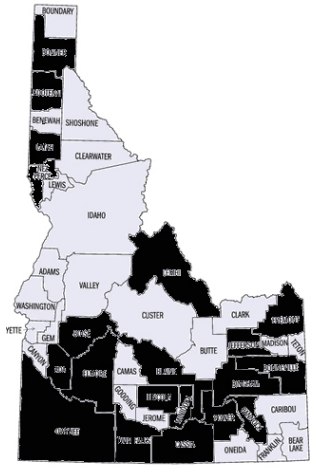
Adams
Benewah
Boise
Bonner
Boundary
Butte
Clearwater
Custer
Fremont
Idaho
Jefferson
Kootenai
Latah
Lemhi
Nez Perce
Valley

Sympetrum pallipes
Striped meadowhawk



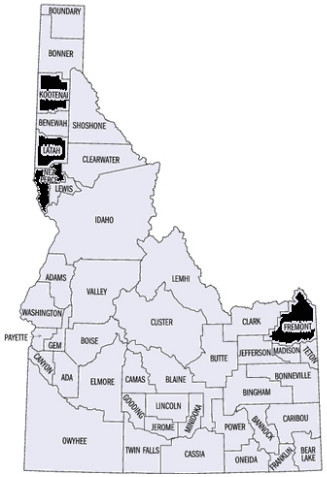
Ada
Bannock
Bear Lake
Blaine
Boise
Bonner
Butte
Canyon
Caribou
Cassia
Clearwater
Franklin
Jefferson
Kootenai
Latah
Nez Perce
Oneida
Power
Shoshone
Valley

Sympetrum semicinctum
Band-winged meadowhawk



Ada
Bannock
Bingham
Blaine
Boise
Bonner
Bonneville
Canyon
Cassia
Elmore
Franklin
Fremont
Gooding
Jefferson
Kootenai
Latah
Lemhi
Lincoln
Minidoka
Nez Perce
Owyhee
Power
Twin Falls

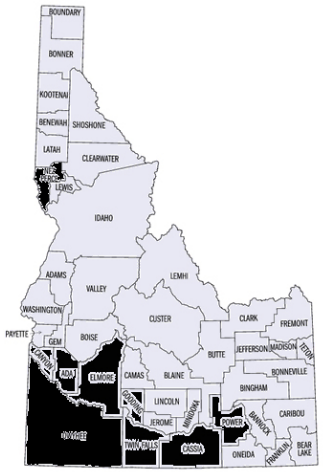
Sympetrum vicinum
Autumn meadowhawk



Fremont
Kootenai
Latah

Tramea Hagen
Saddlebags

Tramea lacerata
Black saddlebags



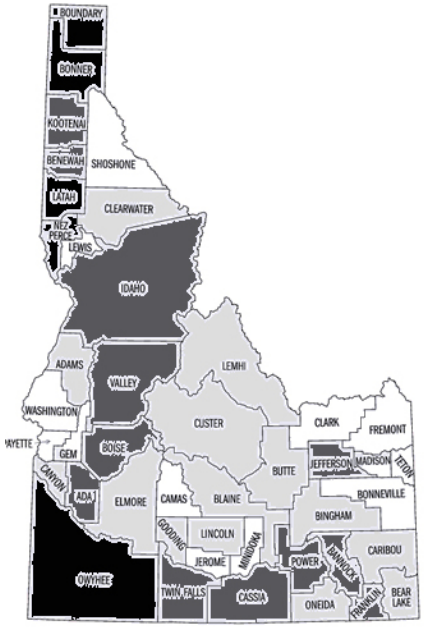
Ada
Canyon
Cassia
Elmore
Gooding
Nez Perce
Owyhee
Power
Twin Falls

ODONATE COLLECTION FREQUENCY BY COUNTIES

The map below shows the number of species recorded in each of the forty-four (44) counties of Idaho. In the opinion of the author, a low number of species collected in a particular county does not necessarily prove a paucity of species present, but may merely represent a low number of collectors/observers working in that county.

The information, however, may prove useful to those odonatists seeking new county records, or who desire to venture into more virgin territory, as they may wish to concentrate on the under-collected areas.

White – <10 species collected/observed
Light Gray – 11-20 species collected/observed
Dark Gray – 21-30 species collected/observed
Black – >31 species collected/observed



THE COUNTY DISTRIBUTIONS

Ada (21):
Amphiagrion abbreviatum
Anax junius
Calopteryx aequabilis
Enallagma boreale
Enallagma carunculatum
Erythemis collocata
Ischnura cervula
Ischnura perparva
Lestes congener
Libellula forensis
Libellula pulchella
Pachydiplax longipennis
Plathemis lydia
Rhionaeschna californica
Rhionaeschna multicolor
Sympetrum corruptum
Sympetrum costiferum
Sympetrum internum
Sympetrum pallipes
Sympetrum semicinctum
Tramea lacerata

Adams (14):
Amphiagrion abbreviatum
Argia emma
Coenagrion resolutum
Enallagma boreale
Ischnura cervula
Ischnura perparva
Lestes isjunctus
Lestes dryas
Libellula quadrimaculata
Plathemis lydia
Somatochlora semicircularis
Sympetrum costiferum
Sympetrum internum
Sympetrum obtrusum

Bannock (28):
Aeshna interrupta
Aeshna palmata
Aeshna umbrosa
Amphiagrion abbreviatum
Anax junius
Argia emma
Enallagma anna
Enallagma annexum
Enallagma boreale
Enallagma carunculatum
Erythemis collocata
Gomphus externus
Ischnura cervula
Ischnura perparva
Lestes congener
Lestes unguiculatus
Leucorrhinia intacta
Libellula forensis
Libellula pulchella
Libellula quadrimaculata
Ophiogomphus severus
Plathemis lydia
Sympetrum corruptum
Sympetrum costiferum
Sympetrum danae
Sympetrum internum
Sympetrum pallipes
Sympetrum semicinctum

Bear Lake (17):
Aeshna constricta
Aeshna umbrosa
Amphiagrion abbreviatum
Anax junius
Argia emma
Enallagma boreale
Enallagma clausum
Ischnura cervula
Lestes congener
Lestes disjunctus
Lestes dryas
Lestes unguiculatus
Libellula quadrimaculata
Sympetrum costiferum
Sympetrum danae
Sympetrum internum
Sympetrum pallipes

Benewah (21):
Amphiagrion abbreviatum
Anax junius
Calopteryx aequabilis
Coenagrion resolutum
Cordulia shurtleffii
Enallagma boreale
Enallagma carunculatum
Enallagma ebrium
Epitheca spinigera
Ischnura cervula
Ischnura perparva
Lestes unguiculatus
Leucorrhinia intacta
Libellula forensis
Libellula pulchella
Libellula quadrimaculata
Ophiogomphus severus
Plathemis lydia
Rhionaeschna californica
Rhionaeschna multicolor
Sympetrum obtrusum

Bingham (16):
Aeshna interrupta
Enallagma anna
Enallagma annexum
Enallagma boreale
Enallagma carunculatum
Enallagma clausum
Ischnura cervula
Ischnura perparva
Lestes congener
Lestes dryas
Rhionaeschna californica
Rhionaeschna multicolor
Sympetrum corruptum
Sympetrum costiferum
Sympetrum danae
Sympetrum semicinctum

Blaine (15):
Aeshna interrupta
Aeshna palmata
Aeshna umbrosa
Calopteryx aequabilis
Coenagrion resolutum
Enallagma boreale
Erythemis collocata
Ischnura perparva
Lestes congener
Lestes dryas
Libellula comanche
Libellula saturata
Sympetrum corruptum
Sympetrum danae
Sympetrum pallipes
Sympetrum semicinctum

Boise (21):
Aeshna interrupta
Anax junius
Argia vivida
Cordulia shurtleffii
Enallagma annexum
Enallagma boreale
Enallagma carunculatum
Erythemis collocata
Ischnura cervula
Ischnura perparva
Lestes congener
Lestes dryas
Leucorrhinia intacta
Libellula forensis
Libellula pulchella
Libellula quadrimaculata
Rhionaeschna multicolor
Sympetrum internum
Sympetrum obtrusum
Sympetrum pallipes
Sympetrum semicinctum

Bonner (36):
Aeshna canadensis
Aeshna constricta
Aeshna eremita
Aeshna interrupta
Aeshna palmata
Aeshna sitchensis
Aeshna tuberculifera
Aeshna umbrosa
Amphiagrion abbreviatum
Anax junius
Cordulia shurtleffii
Enallagma annexum
Enallagma boreale
Enallagma ebrium
Epitheca spinigera
Gomphus graslinellus
Ischnura cervula
Ischnura perparva
Ladona julia
Lestes congener
Lestes disjunctus
Lestes unguiculatus
Leucorrhinia intacta
Leucorrhinia proxima
Libellula forensis
Libellula pulchella
Libellula quadrimaculata
Ophiogomphus severus
Plathemis lydia
Rhionaeschna californica
Somatochlora semicircularis
Somatochlora walshii
Sympetrum anae
Sympetrum obtrusum
Sympetrum pallipes
Sympetrum semicinctum

Bonneville (2):
Enallagma boreale
Sympetrum semicinctum

Boundary (36):
Aeshna canadensis
Aeshna eremita
Aeshna interrupta
Aeshna juncea
Aeshna palmata
Aeshna umbrosa
Amphiagrion abbreviatum
Anax junius
Coenagrion resolutum
Cordulia shurtleffii
Enallagma annexum
Enallagma boreale
Enallagma carunculatum
Enallagma ebrium
Epitheca spinigera
Ischnura cervula
Ischnura perparva
Ladona julia
Lestes congener
Lestes isjunctus
Lestes forcipatus
Lestes unguiculatus
Leucorrhinia intacta
Leucorrhinia proxima
Libellula forensis
Libellula pulchella
Libellula quadrimaculata
Nehalennia irene
Ophiogomphus severus
Rhionaeschna californica
Somatochlora albicincta
Somatochlora semicircularis
Sympetrum costiferum
Sympetrum danae
Sympetrum internum
Sympetrum obtrusum

Butte (12):
Aeshna interrupta
Aeshna palmata
Amphiagrion abbreviatum
Enallagma boreale
Ischnura perparva
Lestes congener
Lestes unguiculatus
Sympetrum corruptum
Sympetrum costiferum
Sympetrum danae
Sympetrum obtrusum
Sympetrum pallipes

Camas (4):
Amphiagrion abbreviatum
Enallagma boreale
Ischnura perparva
Lestes unguiculatus

Canyon (13):
Anax junius
Argia emma
Calopteryx aequabilis
Enallagma carunculatum
Erythemis collocata
Ophiogomphus occidentis
Pachydiplax longipennis
Rhionaeschna californica
Sympetrum corruptum
Sympetrum internum
Sympetrum pallipes
Sympetrum semicinctum
Tramea lacerata

Caribou (15):
Aeshna constricta
Aeshna interrupta
Amphiagrion abbreviatum
Enallagma anna
Enallagma annexum
Ischnura cervula
Ischnura perparva
Lestes congener
Lestes dryas
Ophiogomphus severus
Sympetrum corruptum
Sympetrum costiferum
Sympetrum danae
Sympetrum internum
Sympetrum pallipes

Cassia (22):
Aeshna palmata
Amphiagrion abbreviatum
Anax junius
Argia vivida
Cordulegaster dorsalis
Enallagma anna
Enallagma annexum
Enallagma carunculatum
Enallagma clausum
Erythemis collocata
Ischnura cervula
Ischnura perparva
Lestes congener
Libellula forensis
Ophiogomphus severus
Rhionaeschna multicolor
Stylurus olivaceus
Sympetrum corruptum
Sympetrum internum
Sympetrum pallipes
Sympetrum semicinctum
Tramea lacerata

Clark (7):
Aeshna eremita
Aeshna palmata
Aeshna umbrosa
Amphiagrion abbreviatum
Argia alberta
Enallagma ebrium
Sympetrum corruptum

Clearwater (17):
Aeshna eremita
Aeshna interrupta
Amphiagrion abbreviatum
Argia emma
Coenagrion resolutum
Cordulia shurtleffii
Enallagma boreale
Ischnura perparva
Lestes dryas
Leucorrhinia glacialis
Leucorrhinia hudsonica
Libellula pulchella
Somatochlora albicincta
Somatochlora minor
Somatochlora semicircularis
Sympetrum obtrusum
Sympetrum pallipes

Custer (12):
Aeshna sitchensis
Amphiagrion abbreviatum
Coenagrion resolutum
Enallagma boreale
Ischnura perparva
Lestes dryas
Leucorrhinia hudsonica
Libellula saturata
Somatochlora semicircularis
Sympetrum costiferum
Sympetrum internum
Sympetrum obtrusum

Elmore (19):
Aeshna interrupta
Amphiagrion abbreviatum
Anax junius
Argia emma
Enallagma anna
Enallagma boreale
Enallagma carunculatum
Enallagma clausum
Erythemis collocata
Libellula forensis
Libellula quadrimaculata
Ophiogomphus severus
Pantala flavescens
Plathemis lydia
Rhionaeschna californica
Rhionaeschna multicolor
Sympetrum corruptum
Sympetrum semicinctum
Tramea lacerata

Franklin (28):
Aeshna interrupta
Aeshna palmata
Amphiagrion abbreviatum
Anax junius
Argia emma
Calopteryx aequabilis
Enallagma annexum
Enallagma boreale
Enallagma carunculatum
Gomphus externus
Ischnura cervula
Ischnura perparva
Lestes congener
Lestes disjunctus
Lestes dryas
Lestes unguiculatus
Leucorrhinia intacta
Libellula forensis
Libellula pulchella
Libellula quadrimaculata
Rhionaeschna californica
Rhionaeschna multicolor
Stylurus olivaceus
Sympetrum corruptum
Sympetrum costiferum
Sympetrum danae
Sympetrum pallipes
Sympetrum semicinctum

Fremont (10):
Aeshna palmata
Enallagma annexum
Enallagma boreale
Leucorrhinia hudsonica
Libellula quadrimaculata
Ophiogomphus severus
Sympetrum corruptum
Sympetrum obtrusum
Sympetrum semicinctum
Sympetrum vicinum

Gem (0):

Gooding (15):
Amphiagrion abbreviatum
Anax junius
Argia vivida
Erythemis collocata
Ischnura cervula
Lestes congener
Lestes unguiculatus
Libellula forensis
Pachydiplax longipennis
Pantala hymenaea
Plathemis lydia
Rhionaeschna multicolor
Sympetrum corruptum
Sympetrum semicinctum
Tramea lacerata

Idaho (24):
Aeshna interrupta
Aeshna palmata
Aeshna umbrosa
Amphiagrion abbreviatum
Argia emma
Argia vivida
Enallagma boreale
Ischnura cervula
Ischnura perparva
Ladona julia
Lestes congener
Lestes disjunctus
Lestes dryas
Lestes unguiculatus
Leucorrhinia hudsonica
Leucorrhinia intacta
Libellula pulchella
Libellula quadrimaculata
Plathemis lydia
Rhionaeschna multicolor
Somatochlora minor
Somatochlora semicircularis
Sympetrum corruptum
Sympetrum obtrusum
Sympetrum pallipes
Sympetrum semicinctum

Jefferson (23):
Aeshna constricta
Aeshna interrupta
Aeshna umbrosa
Amphiagrion abbreviatum
Coenagrion resolutum
Enallagma boreale
Enallagma carunculatum
Enallagma ebrium
Ischnura cervula
Lestes congener
Lestes disjunctus
Lestes dryas
Lestes unguiculatus
Leucorrhinia intacta
Libellula pulchella
Libellula quadrimaculata
Rhionaeschna multicolor
Sympetrum corruptum
Sympetrum costiferum
Sympetrum internum
Sympetrum obtrusum

Jerome (1):
Libellula forensis

Kootenai (24):
Aeshna interrupta
Aeshna palmata
Aeshna umbrosa
Amphiagrion abbreviatum
Enallagma boreale
Enallagma carunculatum
Enallagma ebrium
Erythemis collocata
Ischnura cervula
Ischnura perparva
Lestes congener
Lestes unguiculatus
Leucorrhinia intacta
Libellula forensis
Libellula pulchella
Libellula quadrimaculata
Pachydiplax longipennis
Plathemis lydia
Rhionaeschna californica
Sympetrum corruptum
Sympetrum obtrusum
Sympetrum pallipes
Sympetrum semicinctum
Sympetrum vicinum

Latah (34):
Aeshna interrupta
Aeshna palmata
Aeshna umbrosa
Amphiagrion abbreviatum
Anax junius
Archilestes californicus
Argia vivida
Calopteryx aequabilis
Enallagma annexum
Enallagma boreale
Enallagma carunculatum
Erythemis collocata
Ischnura cervula
Ischnura perparva
Lestes congener
Lestes unguiculatus
Leucorrhinia intacta
Libellula forensis
Libellula pulchella
Libellula quadrimaculata
Ophiogomphus severus
Pachydiplax longipennis
Plathemis lydia
Rhionaeschna californica
Rhionaeschna multicolor
Somatochlora albicincta
Somatochlora minor
Sympetrum corruptum
Sympetrum illotum
Sympetrum internum
Sympetrum obtrusum
Sympetrum pallipes
Sympetrum semicinctum
Sympetrum vicinum

Lemhi (20):
Amphiagrion abbreviatum
Anax junius
Coenagrion resolutum
Enallagma annexum
Enallagma boreale
Enallagma carunculatum
Ischnura perparva
Lestes congener
Lestes dryas
Lestes unguiculatus
Leucorrhinia hudsonica
Leucorrhinia intacta
Leucorrhinia proxima
Libellula quadrimaculata
Rhionaeschna multicolor
Sympetrum corruptum
Sympetrum costiferum
Sympetrum internum
Sympetrum obtrusum
Sympetrum semicinctum

Lewis (2):
Enallagma annexum
Enallagma boreale

Lincoln (12):
Argia emma
Calopteryx aequabilis
Enallagma anna
Enallagma boreale
Enallagma carunculatum
Enallagma clausum
Ischnura perparva
Lestes congener
Lestes unguiculatus
Ophiogomphus severus
Sympetrum corruptum
Sympetrum semicinctum

Madison (2):
Aeshna constricta
Lestes congener

Minidoka (6):
Enallagma boreale
Enallagma carcunculatum
Ischnura perparva
Lestes congener
Sympetrum costiferum
Sympetrum semicinctum

Nez Perce (31):
Aeshna palmata
Aeschna umbrosa
Amphiagrion abbreviatum
Anax junius
Archilestes californicus
Argia vivida
Enallagma carunculatum
Erythemis collocata
Ischnura cervula
Ischnura perparva
Lestes congener
Lestes disjunctus
Lestes unguiculatus
Leucorrhinia intacta
Libellula forensis
Libellula pulchella
Libellula quadrimaculata
Ophiogomphus occidentis
Pachydiplax longipennis
Plathemis lydia
Rhionaeschna californica
Rhionaeschna multicolor
Stylurus olivaceus
Sympetrum corruptum
Sympetrum costiferum
Sympetrum illotum
Sympetrum obtrusum
Sympetrum pallipes
Sympetrum semicinctum
Sympetrum vicinum
Tramea lacerata

Oneida (14):
Aeshna sitchensis
Amphiagrion abbreviatum
Argia emma
Enallagma anna
Enallagma carunculatum
Erythemis collocata
Gomphus externus
Ischnura perparva
Lestes congener
Lestes dryas
Lestes unguiculatus
Libellula pulchella
Sympetrum corruptum
Sympetrum pallipes

Owyhee (33):
Amphiagrion abbreviatum
Anax junius
Argia alberta
Argia emma
Argia vivida
Calopteryx aequabilis
Enallagma anna
Enallagma annexum
Enallagma boreale
Enallagma carunculatum
Enallagma clausum
Erpetogomphus compositus
Erythemis collocata
Ischnura cervula
Ischnura denticollis
Ischnura perparva
Lestes dryas
Libellula comanche
Libellula forensis
Libellula nodistica
Libellula pulchella
Libellula quadrimaculata
Libellula saturata
Macromia magnifica
Ophiogomphus severus
Pachydiplax longipennis
Plathemis lydia
Plathemis subornata
Progomphus borealis
Rhionaeschna multicolor
Sympetrum corruptum
Sympetrum semicinctum
Tramea lacerata

Payette (0):

Power (27):
Aeshna interrupta
Aeshna palmata
Amphiagrion abbreviatum
Anax junius
Argia alberta
Argia emma
Argia vivida
Enallagma anna
Enallagma boreale
Enallagma carunculatum

Enallagma clausum
Ischnura cervula
Ischnura perparva
Lestes congener
Lestes dryas
Lestes unguiculatus
Libellula forensis
Pantala flavescens
Rhionaeschna multicolor
Stylurus olivaceus
Sympetrum corruptum
Sympetrum danae
Sympetrum internum
Sympetrum madidum
Sympetrum pallipes
Sympetrum semicinctum
Tramea lacerata

Shoshone (7):
Aeshna constricta
Aeshna palmata
Libellula pulchella
Somatochlora semicircularis
Sympetrum corruptum
Sympetrum illotum
Sympetrum pallipes

Teton (3):
Aeshna palmata
Libellula quadrimaculata
Ophiogomphus severus

Twin Falls (21):
Aeshna palmata
Amphiagrion abbreviatum
Anax junius
Argia emma
Argia vivida
Calopteryx aequabilis
Enallagma anna
Erythemis collocata
Ischnura cervula
Ischnura perparva
Libellula forensis
Libellula saturata
Ophiogomphus severus
Pachydiplax longipennis
Pantala flavescens
Plathemis lydia
Rhionaeschna multicolor
Sympetrum corruptum
Sympetrum internum
Sympetrum semicinctum
Tramea lacerata

Valley (24):
Aeshna interrupta
Amphiagrion abbreviatum
Argia vivida
Calopteryx aequabilis
Coenagrion resolutum
Cordulia shurtleffii
Enallagma boreale
Enallagma carunculatum
Gomphus kurilis
Ischnura cervula
Ischnura perparva
Lestes disjunctus
Lestes dryas
Lestes unguiculatus
Leucorrhinia hudsonica
Leucorrhinia intacta
Libellula quadrimaculata
Libellula saturata
Ophiogomphus severus
Somatochlora semicircularis
Sympetrum costiferum
Sympetrum danae
Sympetrum obtrusum
Sympetrum pallipes

Washington (0):

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Dennis Paulson's *The Dragonflies (Odonata)* of Idaho was the starting point for the research, along with Thomas W. "Nick" Donnelly's groundbreaking Dot Map Project, which formed the foundation for much of the distribution information contained on Odonata Central, the brainchild of Dr. John Abbott at the University of Texas. This effort would have been impossible without the convenient databank found therein, encompassing both the Dot Map data plus personal collection data from odonatists throughout the country.

Most of the data contained herein comes from the Dot Map Project, with only a small portion being contributed by individual collectors on Odonata Central. Of the 799 confirmed Odonata Central records for Idaho, as of the initial preparation of this document, fully 703 (87.98%) are the result of the Dot Map Project, leaving only 96 submissions by individual collectors: Keith Carlson, Randall Cox (Wyoming), Sid Dunkle (Arizona), Doug Ellis, Kent Fothergill (Tennessee), Larry Hamrin, L. S. Hawkins, Gary Henning, Dan Jackson (Wisconsin), Jim Johnson (Washington), Greg Lasley (Texas), Ron Lyons (Oregon), Neil McDonal, Alan Myrup (Utah), Dennis Paulson (Washington), Kelby Ouchley (Louisiana), Julie Riddle (Idaho), Charles Swift, David F. Whitacre.

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A Review of Research on Student Learning with Implications for Teaching College Science in Idaho

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Abstract

The purpose of this manuscript is to review research from the fields of biology, education, psychology, and others regarding how students learn and then use this information to propose a new curricular paradigm for teaching college science in Idaho. Scholars have devoted considerable time to ideas such as how students learn, how faculty teach, and what constitutes best practices in education. However while no clear consensus exists regarding a specific model for teaching generally, or for teaching college science specifically, there are several emerging themes that should be considered best practices and incorporated into undergraduate science instruction. We reviewed the primary literature regarding student learning, faculty teaching, and emerging themes in education and offer a framework for curriculum design and classroom instruction.

Keywords: **learning, active, inquiry, research, college, teaching, science**

The purpose of this manuscript is to review research from the fields of biology, education, psychology, and others regarding how students learn and then to use this research to propose an approach to teaching science in Idaho's colleges and universities. Research in learning has an important role (NSTA, 2010) and a long history beginning in the early 20th Century (Sawyer, 2006). It began as a response to *instructionism*, an educational paradigm designed to prepare young people for entry into the workforce of the late 1800s and early 1900s. As the needs of society changed, however, from students prepared for an industrial workforce to those prepared for an innovation workforce, educational practice changed too (Sawyer, 2006). Today science educators and researchers are again advocating for change based on a growing understanding of how students learn (Donovan *et al.*, 1999; DeHaan, 2005; Bransford *et al.*, 2006; AAAS, 2011). Indeed, the research literature from the fields of biology, chemistry, education, neuroscience, physics, psychology, and sociology has grown so vast that a comprehensive treatment of the subject is untenable for the practicing educator. New developments on how students learn, educational psychology, and educator practice are transforming our profession both in the lecture hall and in the lab (Collins, 2006; Sawyer, 2006; NRC, 2011). Professional scientific societies such as the American Association for the Advancement of Science (AAAS) have joined forces with educators, researchers, administrators, and states to review research literature, debate best practices, and propose a contemporary framework for science education in American public schools at all levels (*i.e.* K – 16). This review will attempt to distill the current understanding of what good educational practice looks like based on the relatively new field of the learning sciences (Sawyer, 2006). The works considered and suggestions offered are targeted to faculty

teaching undergraduate biology coursework in Idaho however the implications of research reviewed transcend disciplines and institutions.

A Brief History of Educational Thought

As societal goals, values, and needs for an educated populace changed, research in education flourished and gave rise to multiple competing philosophical positions regarding what education should look like (Paul, 2005). Philosophers lead the transformation in education. Individuals including Karl Popper, John Dewey, and Jean Piaget promoted divergent views such as post-positivism, pragmatism, and constructionism, respectively (Paul, 2005; Kafai, 2006, Gutek, 2011). Research followed these *avant-garde* philosophers and today there are numerous journals addressing issues of educational practice, reform, and research. Science education research, and the practice of science education, has lagged behind other academic disciplines for a variety of reasons (DeHaan, 2005; Wieman, 2009), particularly at the college level. Therefore, as considerable work has been conducted with primary and secondary school-aged children, findings and suggestions from these studies, where applicable, will be included.

Research on Student Learning

People learn in both formal and informal settings (Bransford *et al.*, 2006). Formal settings include the familiar classrooms and laboratories that we, in academia, have all experienced. Informal settings, however, also produce significant learning gains. These may include social settings like the workplace, job site, playground, chat room, community center or social club (Bransford *et al.*, 2006). In many situations, informal settings may be preferable to formal settings for learning. For example, in conjunction with reflecting on learning activities, students might use an online discussion board to interact with peers, make tentative conjectures, test ideas, and refine their understanding of a concept or topic. This type of learning is both informal and social and it takes place in a low-risk environment that may be more attractive to today's students no matter how "relaxed" we try to make our formal learning environments.

Bransford *et al.* (2006) reviewed developments in how students learn from cognitive science and state that there are two pathways to become experts at something; by routine or by adaption. Routine expertise is achieved, essentially, through repetition even if this expertise is in the realm of higher cognitive function; a task that an adult might perform, for example. Similarly, children learn by imitation (Bransford *et al.*, 2006) so it may be that a range of learners will discover the process of science by imitating us as we model the process in our classrooms and laboratories as Sawyer (2006) has suggested. More useful is adaptive expertise. This form of expertise is accomplished by integrating various types of learning activities into the curriculum. For example, learning activities should be diverse and responsive to students' needs with a focus on conceptual understanding, discovering new knowledge, collaboration, appropriate scaffolding, and deep reflection (Sawyer, 2006). This is consistent with Kolb's (1984) learning styles of experience and conceptualization. Students can learn how to efficiently solve problems (*i.e.* experience) but by utilizing an adaptive expertise approach, students will also learn how to adapt to novel situations (*i.e.* conceptualize); adopting new tools to help them solve new problems.

Adults learn differently than children (Fiser, 2008) and while many of the basic methodological principles may be transferable, just how adults learn differently should be considered explicitly by faculty in higher education. Merriam reviewed Malcolm Knowles concept of andragogy; the art and science of helping adults learn (Merriam, 2001). She discussed five characteristics of adult learners that differentiated adults from young adults or children. Adult learners 1) have an independent self-concept and can direct this to their own learning, 2) have a rich reservoir of life experiences to situate learning within, 3) have different social forces influencing their learning, 4) are interested in applying new knowledge immediately, and 5) are motivated by internal factors (like an independent self-concept) as opposed to external factors (like parents!). Merriam (2001) points out, however, that many adults desire or need strong guidance (*i.e.* not #1 above) while some children do possess an independent self-concept. The distinctions between children and adults, in learning, are not as clean as the practicing educator might wish. As andragogy as a conceptual framework evolved, Knowles moved from a position of contrasting andragogy to pedagogy to a position acknowledging a continuum of learning from teacher-directed to student-directed, respectively (Merriam, 2001). Regardless of interpretation, androgogy as a conceptual framework for education is not widely discussed in North America or the U.K. Instead, a synonymous term, adult education, is used where andragogy is but one model of how educating adults should proceed (Merriam, 2001). And Knowles model, Merriam (2001) suggests, is still valid and to consider adult education without considering Knowles ideas is inconceivable. Knowles suggested three principles for educating adults that includes 1) an emphasis on learning techniques, 2) an emphasis on practical application, and 3) learning to learn from experience (Knowles, 1972). As we will discuss below, these ideas will not disappear over the next 40 years of educational research.

Not only do adults have different learning characteristics (Merriam, 2001), their cognitive ability is different from that of adolescents (Fiser, 2008). Complicating this fact of neurobiology is the concomitant fact that our classrooms may be filled with students at very different levels of brain development. Adolescents aged 13 to 19 have a less developed ability to reason conceptually (Fiser, 2008) than do older individuals. It isn't until age 23 to 25 that most adults acquire the cognitive ability to combine multiple abstractions and synthesize them into a larger conceptual understanding (Fiser, 2008). Our challenge, of course, is that changing demographics in higher education results in a diversity of students in our classrooms with a wide range of cognitive maturity. For example in 2013, 45% of degree-seeking students at the College of Western Idaho were older than 25 years of age (CWI, 2013). Therefore, faculty are teaching to students with varying levels of cognitive maturity making classroom instruction more difficult.

Kolb & Kolb (2009) discuss learning in education in the context of their spiral learning cycle of experiential learning. This concept posits that learners prefer different styles (experience, reflection, conceptualization, or actualization) and modes (concrete experience, reflective observation, abstract conceptualization, and active experimentation) and that the interplay between these styles and modes can be conceptualized as a cyclical, or spiral, process.

Bransford *et al.* (2006) would likely consider experiential learning both an informal and social learning setting. We believe what matters; however, in this context is the place in which the learning happens. For example, many students

enter biological fields following a passion for the outdoors. When one is passionate about something, that *thing* becomes very important; that is, the student has something at stake. In this context, bringing the learning experience outdoors, in whole or in part, involves all the student's faculties (sight, sound, smell, touch, cognition, and even taste!) and may better facilitate learning. Similarly, Kuh (1995) wrote that, "Out-of-class experiences presented students with personal and social challenges, encouraged them to develop more complicated views on personal, academic, and other matters, and provided opportunities for synthesizing and integrating material presented in the formal academic program" (p. 146).

Kuh (1995) found that the informal social setting of experiential learning provided students the opportunity to concretize abstractions or concepts from the formal learning environment.

Hickcox (2002) suggests that no single hypothesis of education is appropriate for every student in all situations and a combination of practices is probably the best design for instruction. She cites the work of David Kolb (1984) and his highly regarded learning style inventory as a model for curriculum design. Kolb proposed that people approach learning from different perspectives; experiencing, reflecting, or conceptualizing, for example (Kolb, 1984). Therefore a successful learning program would incorporate multiple learning styles (Hickcox, 2002) and these should be cyclical or repetitive (Kolb & Kolb, 2009) in order to reach as many students as possible during the period of learning.

Research on Teaching

In addition to the physiological development of our students, the educational practices of our faculty influence learning (Sawyer, 2006; Deslauriers, Schelew, & Wieman, 2011). Just what practices, however, are "best" remains a topic of considerable discussion and much research continues in an attempt to develop a comprehensive model for teaching in higher education. For the greater part of the 20th Century, American education was influenced by the post-positivist philosophy of science and, subsequently, education (Paul, 2005). Instruction was expositional, consisting primarily of lecture with little or no engagement of students (Allen & Tanner, 2009). This may be because scientists (and, thus, college professors) were trained by scientists and not educational researchers (Slater, Slater, & Bailey, 2010). It is generally not the case that these scientist/educators do not care about their teaching; rather, they are either ignorant or skeptical of educational research and findings (Slater *et al.*, 2010). This paradigm has shifted, however, and over the past few decades there has been a revolution slowly brewing in science education (DeHaan, 2005).

Emerging Themes from Educational Research

Fortunately for the college professor there have been several excellent reports and texts in the past ten years on best practices in science education as reviewed by educational researchers (Handelsman, Miller, & Pfund, 2007; AAAS, 2011; Allen & Turner, 2009; NRC, 2011). What follows is a brief discussion of what has been reviewed and synthesized from the diverse field of the learning sciences.

Research in the learning sciences, generally with K-12 students, has converged on several themes for improving educational practice in the

technologically-driven 21st Century. These include: 1) the importance of a deeper conceptual understanding, 2) a focus on learning as well as teaching, 3) creating learning environments, 4) the importance of the learner's prior knowledge, and 5) the importance of active reflection (Sawyer, 2006). The AAAS (2011) has recommended the following core competencies for undergraduate biology instruction: 1) the ability to apply the process of science, 2) the ability to use quantitative reasoning, 3) the ability to use modelling and simulation, 4) the ability to recognize and develop an interdisciplinary ethos, 5) the ability to communicate and collaborate with others, and 6) the recognition of the connection between science and society. All of the teaching practices below (active-learning, cognitive apprenticeships, and scaffolding) support these six competencies.

Active-Learning

Active-learning is promoted by advocates as a way to improve student learning by engaging students directly in the learning process (Wilke, 2003; Freeman *et al.*, 2014). For example, Freeman *et al.* (2014) conducted a meta-analysis of 225 studies and found that students enrolled in an active, student-centered course had a failure rate 12% lower than students enrolled in an exposition-styled course. Wilke (2003) describes active-learning as "students doing things and thinking about the things they are doing" (p. 207). Things that students might do include refining their science process skills. This means working through the scientific process in a structured, scaffolded environment. It might include the student developing multiple hypotheses that could be tested, designing experiments, collecting and analyzing data, and presenting that data graphically, in writing, or by way of presentations. These are the skills used by scientists that students need time to explore in a safe and controlled environment. Active-learning may also coach students in the use of higher order thinking skills. In Blooms Taxonomy, the cognitive levels of synthesis and evaluation are higher order thinking skills and can be supported by faculty. For example, faculty might present challenging questions to students and then model the appropriate behavior for working through those problems (Collins, 2006). After modelling an effective approach to addressing a complex problem, we might present students with a similar problem and coach them through the process of solving the problem. The instructional approach of modelling, coaching, and scaffolding (see below) are hypothesized to be of value in student learning (Collins, 2006). Indeed in one of the best recent examples of such research utilizing an evidentiary standard, Deslauriers *et al.* (2011) used their entire class time to engage students in thinking scientifically; making scientific arguments, testing predictions, and solving problems. As students engaged in thinking scientifically, they were actively coached and scaffolded by their peers and professors. Perhaps more simplistically, faculty can engage students in learning by the use of simple activities. For example in our introductory biology courses we've asked students to draw illustrations of complex biological molecules, work in groups to solve problems, or evaluate simple cases that can be completed in 20 minutes or less. All of these are examples of "doing things" and incorporating self-reflection, journaling for example, brings in the important piece that Wilke (2003, p. 207) described as "thinking about the things they are doing."

Cognitive Apprenticeships

A particularly attractive alternative to traditional laboratory instruction is the cognitive apprenticeship model (Collins, 2006) whereby students engage in the scientific process from beginning to end (Switzer & Shriner, 2000; Hofstein, 2004; Collins, 2006). Guided, inquiry-based laboratory work has been demonstrated to be more effective than traditional verification labs (Blanchard *et al.*, 2010). Apprenticeships give students opportunities to engage with and model expert behaviors as they work alongside experts and a community of peers to solve authentic problems (Collins, 2006). Utilizing the apprenticeship model may be a powerful tool as we realign the focus of laboratory work from verification labs to those that emphasize science process skills (Eylon & Linn, 1988; Switzer & Shriner, 2000). Modeling behaviors that we want students to perform and then coaching them through similar tasks allows students to acquire a complex set of skills in a guided yet exploratory situation. To implement a cognitive apprenticeship, instructors would *model* the process of science by elaborating on a project they've completed (from start to finish, both descriptive and experimental), *coach* students with regard to their own projects, *scaffold* their learning as they are coaching them, and provide a *community of learning* in the context of lab groups that are working on novel problems they've come up with themselves (Collins, 2006).

Scaffolding

The examples of active-learning teaching practices above that engage students and explore issues are consistent with the patterns, principles, processes, and themes described by researchers (Knowles, 1972; Kolb, 1984; Sawyer, 2006; AAAS, 2011; Freeman *et al.*, 2014). However, as with any instructional model, *scaffolding* of student learning should be employed. Learning scientists refer to scaffolding as "the help given to a learner that is tailored to that learner's needs in achieving his or her goals of the moment" (Sawyer, 2006; p. 11). It is not help in terms of giving the learner the steps necessary to solve a problem, rather it is help provided to the student so she can derive the necessary steps herself. It involves prompts and questioning to move the learner in the right direction so he can discover for himself the correct answer or process. Successful science instruction will scaffold learners' active knowledge development.

A Framework for Science Education

Curriculum Design

Curriculum should be designed following the backward design approach of Wiggins & McTighe (1998). Backward design forces faculty to consider the desired outcomes of instruction and then work backwards to develop assessment strategies and classroom practice. Curriculum should incorporate activities and techniques to reach the multiple learning styles of students (Kolb, 1984, Hickcox, 2002). For example to reach adult students, activities and content should emphasize technique, application, and how to positively incorporate previous life experiences (Knowles, 1972). Our courses should be designed to create a rich environment for students including social interactions, physical experiences, and new situations (Bransford *et al.*, 2006) that are relevant to students' lives or potential careers. We should be adaptive in nature, incorporating various types

of instructional activities because of the differences between younger adults and older adults (Fiser, 2008) and different learners (Kolb & Kolb, 2009). And we should focus on conceptual understanding and science-process skills as broad curriculum objectives.

Instructional Practice

Combining the general themes and specific examples we've reviewed into a framework for science education, we can envisage a model of instruction that encourages the development of a collaborative learning community in lecture and a cognitive apprenticeship in the laboratory (Figure 1). The lecture would engage students and explore issues with an active, student-centered, and inquiry-based instructional approach (Wilke, 2003; Kafai, 2006; Kirschner *et al.*, 2006; Hmelo-Silver *et al.*, 2007; Yager, 2009, AAAS, 2011; Deslauriers *et al.*, 2011. Freeman *et al.*, 2014). Opportunities for reflection and self-directed learning would reinforce the issues, provide students the flexibility to manage their own learning, and create formative assessment measures. Multiple, low-stakes quizzes and exams, with a focus on conceptual understanding, can be used as summative assessments and one part of an evaluation of student achievement. In lab we would develop a cognitive apprenticeship to model and get students thinking about the process of science like scientists (Wilke & Straits, 2005). In science, as in other fields, research suggests that students learn more and better when they are actively engaged in scenarios that model professional practice (Sawyer, 2006). All of instruction should support collaboration and community building via in-class, out-of-class, online, informal, and/or social activities and experiences.

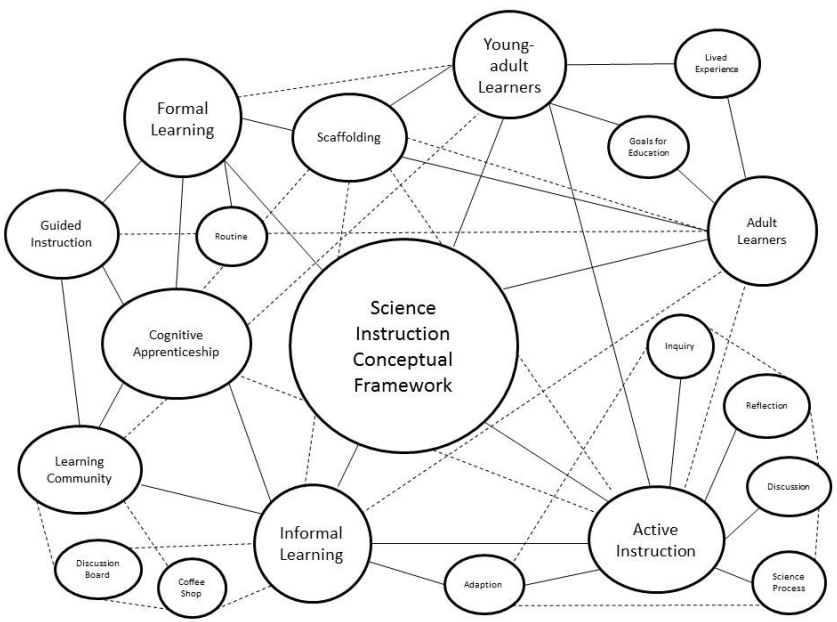

Figure *Graphic organizer representing a conceptual framework for instructional practice in higher education. Solid lines represent primary connections, broken lines are secondary connections. Additional connections exist but have been omitted for clarity.*

Summary Remarks

While the AAAS (2011) recommends a focus on conceptual understanding and student-centered learning environments, a reformed pedagogy does not preclude the value of recitation and foundational information such as facts and processes. Rather, it improves on this knowledge by providing the learner with the ability to utilize this information in novel situations. For example, some researchers have advocated for active-learning strategies and learner construction of knowledge as opposed to the learner as the recipient of an instructor's knowledge (Switzer & Shriner, 2000; Deslauriers, Schelew, & Wieman, 2011). Again, this theme does not remove the importance of the teacher; rather, it changes her role to one of a facilitator of learning as opposed to a transmitter of knowledge. The creation of learning environments deals with making schools places of exploration, places where students can use baseline knowledge to address "real world" problems and processes (we use quotations around this phrase because what authors, and educators, mean by this phrase is actually *contrived scenarios that mimic problems routinely encountered by practitioners in a particular field*). For the teacher, this concept provides the justification for taking chances. The acquisition of new knowledge is not a linear path, it is more often characterized by trial and error, asking the wrong questions, dead ends, and restarts. This *is* the process of science and as science educators we should incorporate this uncertainty into instruction. In engaging classrooms, the learner is given the opportunity to apply knowledge, ask questions, practice processes, and be wrong in the safety of the learning environment where error is not a failure but a "real world" outcome and a teachable moment. Some might describe this model as *inquiry-based instruction* but it much more than simple inquiry. For example, the importance of building on the learner's preexisting knowledge is an important and challenging concept emerging from the learning sciences (DeHaan, 2005; Sawyer, 2006) but is not generally associated with IBI (NSTA, 2004). It's important because if the learner's prior knowledge is not acknowledged, then any new information that is inconsistent with their prior knowledge may be seen with skepticism or contempt. It's challenging because sometimes the learner's preexisting knowledge is incorrect and the job of the teacher is to transform the misconception into a conceptualization that is consistent with the current knowledge base. For example, most learners will have a hypothesis regarding why trees lose their leaves in the fall and this may be partially correct or it may be wholly inaccurate. The truth is a complex relationship between air temperature, photoperiod, and plant hormones and the teacher's job is to get the student to this new understanding without disrespecting her prior knowledge in the process. The importance of reflecting on an experience is because it is during this process of thinking deeply about an event that the learner really has an opportunity to analyze his state of knowledge (Linn, 2006; Sawyer, 2006). In our experience, when we are compelled to talk or write about our knowledge on a particular subject, the process of thinking deeply about my words enhances our ability to situate a developing understanding into a larger context. Research in the learning sciences has demonstrated that these themes, at least within the context of the studies reviewed, maximize learning (Collins, 2006; Kafai, 2006; Sawyer, 2006). What follows necessarily is the need for rigorous, externally valid research to test the hypothesis proposed here and we look forward to Idaho scientist's and scholar's approach to this call.

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CERTAIN FIELD MEASURES OF CHARACTERISTICS AFFECTING WETTED BIOREFUGES IN THE STEPPE/ MONTANE ALTITUDINAL ZONES OF THE SAWTOOTH NATIONAL FOREST, IDAHO

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ABSTRACT

This report is an update of a descriptive 2011 article (J. IAS;1; 1-24) on Biorefuge habitats studied within seven Watersheds of the Sawtooth National Forest (Idaho) This *Pro Bono* ecological field study, defining and assessing field measureable characteristics related to upland Biorefuges, began in the summer season of 2001. The study has continued for thirteen consecutive summers and this report intends to bring pertinent study results and conjectures current to the 2014 field season.

This report concerns particulars of segments of continuing study; Biorefuge makeup, Watershed segregation and biological influences and levels of coliform contamination of adjacent waters.

Biorefuges are here defined as examples of perennial, recognized forage grass producer stands within broader, upland waterside plant communities. They are found on soils intrusively wetted by adjacent surface waters during the growing season. The consistent access to water, the compositions of grazing forage genera and the implied resilient presence of such perennial stands also suggest the consideration of sustaining Biorefuges as a type of ecosystem reserves. In these times of climatic change such possibly flexible habitat components may assume some ecosystem-wide importance.

Within seven topographically defined Watersheds, shallow water measurements including temperature, pH and TDS (Total Dissolved Solids) have been made, focusing on Biorefuge soil wetting, adjacent surface waters. The records now contain some 600 sample sets. The definitions for characteristics of the Watersheds and waters sampled, with the field methods and observations employed, were detailed in the lead publication. The continuing study has reinforced Watershed separation criteria by observing clustered TDS field measure data from the designated Forest Watersheds.

With an eye to user well-being, observed defecating habits of grazing and browsing animals and unsanitary upstream human impacts suggested field testing for the presence of coliform bacteria in influential Biorefuge waters. All waters subject to such tests (15 to date) showed a qualified presence of coliform

bacteria as expected. Seven quantitative incubating plate protocols showed two samples positive for *Escherichia coli* (*E. coli*). One plate count indicated seriously contaminated water in the Shoshone Basin (Watershed #2). Coliform tests remain in progress. Positive readouts, particularly of *E. coli*, suggest the desirability of more sophisticated, laboratory testing by responsible agencies.

INTRODUCTION

Biorefuge entities chosen for study on Sawtooth National Forest lands display persisting ecotonal transition conditions between temperate Ecoregion expressions (after Bailey, 1998). They are broadly represented as Semi-deserts (generally lower elevation) and (upper) Steppe-coniferous (often called lower montane) forest. The former (lower expression) is also called *sagebrush steppe*. I have chosen the appellation Steppe/Montane as aptly descriptive for this study.

Biorefuges studied in this ongoing *Pro Bono* field effort are localized, productive, hydric to mesic habitat bases apparently resilient for food web resource connections and consumer cover. They are observed and evaluated for availability of water, for forage production for grazing consumers, as well as those soil functions where moisture and decomposition are judged. They provide food supplies for primary and secondary consumers of living and dead above and below ground plant materials and other detritus. The Biorefuges of interest here and the Watersheds in which they were studied are detailed for description and practiced field method test procedures in the lead report (Amundsen, 2011).

This study has proceeded from the growing season of 2001 to 2013, first emphasizing habitat related surface water conditions in seven topographically describable Watersheds. All are situated within the boundaries of units of the Sawtooth National Forest in central southern Idaho. Biorefuges within these Watersheds are, holistically considered, identified overall as comparatively diverse, subsurface wetted ecotonal plant communities. Effective substrate—intrusive waters sustain hydric to mesic communities. The surface water supplies continue to be regularly evaluated in field seasons. Unlike the now determined, remarkably segregated, TDS (Total Dissolved Solids) values by Watershed, water temperature and pH (measures taken from ~10cm depth when possible), simply show expected regional or transient micro-- conditions. The temperatures of surface waters are locally influenced, particulaly by shading or the emersion of various types of springs unseen beneath surface waters. Variations of ordinarily basic pH occur, especially in the (sometimes otherwise not indicated) photosynthetic zones of submersed aquatic plants and algae. These measures (degrees Celsius and pH) are kept in field notes and were summarized in the lead publication in 2011. Neither appears to be related to visible variations in extant conditions of terrestrial habitat expressions as studied.

These impacting waters are mostly the result of springtime melt and runoff from so far experienced, higher altitude, snow packs. Biorefuge environment sites here at lower elevations, generally show conditions where evaporation likely exceeds direct precipitation (E>P). Twin Falls ID (elevation about 1220m or 4000 ft. msl), has developed in a (*sagebrush steppe*) semi-desert environment roughly in the geographic center of the Sawtooth National Forest outlying units. Twin Falls has a yearly total precipitation average of less than 10 inches (ca. 250mm).

This update report shows a continuing TDS ranked divisions which are recognized amongst the seven Watersheds considered in the study. There are rare overlaps of values, using clustered TDS reading means. The 13 years of this effort shows no trends in growing season monitored TDS measures with neither up or down numerical mean changes of relative ranking of Watershed positions from high to low.

In continuation of value judgments for Biorefuge components affecting obvious segments of the food web, and in consideration of recreational stakeholders and scattered residents of the highland landscapes, testing for water borne coliform bacteria in influential and intrusive waters has been undertaken.

BIOREFUGES STATUS AND POTENTIAL

Consumer supporting Biorefuges as studied are rich in forage grass genera in highland locations that are marginally in contact with accessible low order stream and small pond surface waters. The Biorefuge expressions incline upwards from accessible water contact through hydric to mesic conditions. Perennial plant stands are sustained by soils intrusively wetted from contacting surface waters. The moistness of the rhizosphere, (rooting zone), demonstrated using simple garden moisture probes, persists throughout critical portions of the growing season (spring floral initiation toward seed set). Key to Biorefuge identity is a predominance of notable taxa of native grasses. Occasional grazer-palatable sedges can be important in places, but the forage availability is generally highlighted by what I designate as an array or *Guild of those grasses similar in habit and multi- replaceability in terms of forage nutrient value*. The typical Biorefuge forage grass genera (considerations of nutritional value at the generic level made *sensu* Hitchcock, 1969) fall into the facultative class of wetland plants (US Fish and Wildlife Svc., 1996). The important guild grass genera, similar in grazing fodder consideration, are perennials of *Festuca* L., *Hordeum* L., *Phleum* L., *Poa* L., *Stipa* L., *Trisetum* Pers., and *Sporobolus* R. Br. (Generic nomenclature/ authority of the Gramineae after Davis, 1952).

Earlier studies within Biorefuges (Amundsen, 2011) showed that the per square meter above ground plant dry weight productivity at seed set maturity was higher in Watersheds #1 than in #2, and higher in #3 and #5 than in #4 and #6 (see Watershed listings following). Dry weights ran generally from 400 to 700 g/m2. The productivity yields roughly supported overall TDS ranking means clusters (discussed below) separating this study's Watersheds.

An experiment (also reported in 2011) with weighed mesh bags of cattail detritus showed a much greater weight loss in bags buried in the more densely fibrous mesic rooting zone of Biorefuges than in more barren semi-xeric soils beyond the Biorefuge expression, under the willow (*Salix* L. spp.) thickets common along streams or under the acid mor humus of the montane coniferous forest, usually upslope. In a possible connection, a recent publication (Hood and Larson, 2014) shows a relationship between predaceous aquatic invertebrate abundance and biodiversity with the physical disruption of terrestrial surfaces (and increase of the extent of adjacent wetted soils) caused by beaver channel excavation. They report declines in pertinent resident predator/prey species richness during droughty seasons with quick recovery post-drought years. A repeated change in

predator and secondary consumer numbers in abutting surface waters suggests a similar relationship between organisms in hydric to mesic soils. Such comparisons were not possible in this field study, although flooded beaver channel excavations were found to increase the breadth of Biorefuges in some cases.

Fluctuations in linked primary and secondary producer populations can be assumed in such instances. Expansion and contraction of suitable wetted Biorefuge habitats by alterations in connecting surface water availability can be expected with episodic climate changes or topical disturbances affecting intrusive water level influences on adjacent sites. In periods of extended drought or conversely as the result of increased available of waters concerned, as with lasting overbank flooding, the Biorefuges would show a possible contracting and expanding expression given a suitable micro-topography (slightly sloping).

In consideration of the overall fitness of the aquatic/terrestrial Biorefuge resource complexes, field testing for often present coliform bacteria, and more particularly for health threatening *Escherichia coli* in the adjacent waters is now included at selected locales (see details following).

WATERSHED IDENTITY

Based on perceptions of landscape dynamics related to topographic exposures and geologic maps, as in the previous report, seven study Watersheds listed below are featured.These Watersheds may contrast in base level geologic substrates at the upper elevations of tributary catch basins (Updated map, Idaho Geologic Survey, 2012). Their directional orientation and surface shading varies and can affects seasonal substrate temperature and moisture dynamics. It is likely that a combination of geologic constituents, seasonality and extent of snow cover, exposure to regional winds, incident sunlight reception (to an extreme of directly beaming on bare ground) and fluctuations in impacting diurnal temperatures can account for most TDS differences in draining streams. These Watersheds are described in more detail with some 57 waters sample locales named on Forest Service Maps (Amundsen (2011).

The seven chosen Watershed units are found with westward draining 2nd order streams (#1, #2), on either side of the southerly draining Big Wood River (#3, #4), along sloping sides of the northerly trending Salmon River Headwaters, HW, (#5, #6). Number 7 is mostly on north side slopes (therefore south draining tributaries) of the westerly trending upper South Fork of the Boise River in the neighborhood of the Camas front.

Central southern Idaho locations for each of the seven Watersheds are listed with approximate "centers" indicated by *Google Earth* derived " Central Area Point" coordinates:

1/Sublette Creek Watershed: A discrete drainage around a common juncture of Cassia, Power and Oneida County boundaries in the Sublette Mountains east of Malta ID. "N 42 20, W 113 00".

2/Shoshone Basin: A discrete drainage basin east of Rogerson ID along the boundary of Twin Falls and Cassia Counties, within the Cassia Mountains (also called the South Hills). "N 42 15, W 114 20".

3/Big Wood River West Draining: Represented by tributaries dissecting the slopes east of the river valley- An area from Ketchum ID north to Galena Summit in Blaine County. "N 43 50, W 114 30".

4/Big Wood River East Draining: Represented by tributaries dissecting the slopes west of the river valley- An area from Ketchum ID north to Galena Summit in Blaine County. "N 43 45, W 114 35".

5/Salmon River Headwaters (HW) West Draining: Represented by tributaries dissecting the slopes east of the river valley- An area from Galena Summit north to Stanley ID, in Blaine and Custer Counties. "N 44 04, W 114 50".

6/Salmon River Headwaters (HW) East Draining: Representing tributaries dissecting the slopes west of the river valley- An area from Galena Summit north to Stanley ID, in Blaine and Custer Counties. "N 44 00, W 114 55".

7/South Fork Boise River- Camas County Front: An area where tributaries trend from north to south along the westerly flowing river, generally north of Fairfield ID in Camas and Elmore Counties. "N 43 30, W 114 55".

The waters characterized in this study (now 600+ sample sets overall) were tested for temperature at 10cm depth, pH and TDS (Total Dissolved Solids) with beneath surface dips, the latter two with "OakTon" battery referenced meters. Water temperature in these highlands (mostly taken mid-day with a shadowed liquid in glass thermometer) was related to the amount of vegetative shading, or in a few cases, to the summertime lower geothermal average temperatures of (sometime stream bottom) virgin springs. Near surface waters with spring-like emissions (often sinking and resurfacing flows in carved stream beds) tend to more closely reflect ambient shallow substrate temperatures. It is interesting to note that fairly robust isolated virgin spring waters do not immediately freeze upon surfacing in wintertime temperatures.

Under a montane coniferous forest overstory an acid humus (*mor*, determined with a Kelway probe) down-flowing catch basin streams showed basic pH readings. These forest stands are often below "naked" alpine substrates. However in Watersheds #4 and #6 with such conditions, only one consistently acidic pH reading was taken in exiting water. This was in pooled stream water in a peat fan below a long dry glacial outwash gully in the East draining Vat Creek, Watershed #6. The pH there was a repeated 6 and the dominant grass guild was rife with an understory of seldom encountered (in this study) sphagnum-like moss.

Temperature, which varied from place to place at 10cm depth in the same waters, and pH, where the instruments often fluctuated by a decimal point or two were not reliable mathematic separators for Watershed distinction. Although the TDS (and pH) meters were calibrated regularly with commercial standards, and showed repeated precision, the accuracy of these field values has not been verified by laboratory bench instruments. For base level comparisons, a set of TDS meters consistently showed readouts of 300 mho in pooled waters of the Camas Centennial Meadows, a recognized Wetland in Camas County (near Fairfield ID). Distilled water shows a TDS of zero as expected with the meters in use.

It is not the field determined numerical values of individually metered TDS

readings, however precise, that demonstrates within Watershed similarity and between Watershed separations. It is the examination of repetitive raw data clustered rankings of TDS means by Watershed from a multitude of (now) 13 seasons of readouts. TDS mean comparisons are the separator(s).

Geophysical characteristics, vegetational expressions and observed substrate surface thermal dynamics, taken together, support the seven differentiations. The lowest TDS readings in the Sublette Basin, Watershed number 2, were always higher than the highest readings from any other Watershed. Given the averages used to define differences over 600 sample field readings in this report, further statistical testing has little meaning other than mathematical exercise. Such determinations were made in the earlier report (Amundsen, 2011) which covered 57 named waters across the seven Watersheds. Analysis of the field data show Standard Error of the TDS means by watershed varied in range between 4.0 and 10.0, considering hundreds of readings.

Comparison of sample number means shows that a distinction or positional value rankings of Watersheds based on means of TDS has not changed relative to the first report, Table 1. In two southern units, the Sublette Creek drainage (Watershed #1) shows the highest TDS of all seven with the Shoshone Basin (#2) the lowest of the seven. In four of the northern five units the mean TDS values of the west draining streams (#3, #5) show higher TDS than opposing east draining streams (#4, #6) along the Big Wood River and Salmon River headwaters (HW). The southerly trending tributary streams sampled along the South Fork of the Boise River-Camas front (Watershed #7) rank higher in TDS than three of the four Wood River or Salmon HW tributaries.

No change or trends in relative Watershed ranking by TDS means was, or is, apparent. Accurate bench laboratory equipment could have somewhat altered errors without disassembling the plotted clusters derived from the large number of field measurements.

(Table 1)

	2001 – 2009		2001-- 2013	
Watershed	Nine Seasons		All Thirteen Seasons	
	# Samples	Mean	# Samples	Mean
1/Sublette	108	420 mho	148	395
2/Shoshone	83	55	121	50
3/Wd Riv west>	56	190	69	180
4/Wd Riv east>	80	100	113	90
5/Slmn HW west>	30	80	36	85
6/Slmn HW east>	59	65	71	60
7/S.Fk Boise R-Camas	30	135	61	115

Table 1, Field measures for number of samples (#) for total dissolved solids (TDS) per designated Watershed unit (see text) followed by clustering means (in mho's). Readouts from the first nine years of growing season Biorefuge study are compared to total readouts and means for thirteen years through 2013. Watershed descriptions and accuracy of field values are discussed in text. There were not any discernable trends for season to season change in the distribution of ranked and clustered means by Watershed across the 13 years. The symbol > indicates the overall drainage direction of the tributary waters measured

In the southern Watersheds, Table 1 shows the Sublette Watershed (#1) with dramatically high TDS means. This overall drainage is open to the west. The TDS distinction is no doubt due to the presence of dissolved solids emanating from a bedrock rich in a limestone complex. Virgin springs, tributaries and main creek are choked with watercress (*Rorippa* Scop. sp.). A small, century old reservoir at the Forest boundary downstream is, anecdotally, a rich sport fishery as are pools in the rather small Sublette Creek.

The lowest TDS values are found in the waters of the Shoshone Basin (#2). Although this Basin is open to the west and the afternoon sun and solar loading is similar to #1 above, the controlling factor is likely the base geology. The Basin is mapped with bedrock of nearly insoluble volcanic rock. Very few vascular aquatic plants are found in the permanent waters.

Table 1 also shows that the west draining tributaries (along both the Big Wood River and Salmon River HW (#3, #5) have higher TDS means than the east draining tributaries of cross valley slopes (#4,#6). With some exceptions, the insolubility of the largely barren alpine bedrock substrates (some exposed in hanging glacial cirques) above the rather narrow drainages is similar on both sides of both rivers. Large glacially related lakes within the western slopes of the Salmon River HW valley are particularly low in the TDS content of easterly draining outlets. Anecdotally, these montane zone lakes now apparently lack the (nutrient contributing) demise of very large, historically reported, migratory fish stocks. No relationship in TDS measures now reflected visible and broadly mapped alpine substrate differences.

One premise is that the less forested westerly and southerly facing slopes (#3, #5) undergo a diurnal freeze-thaw disruption of comparatively extensive (in #4, #6) un-forested and otherwise less shaded surface soils. This temperature change occurs with night time freeze and sunny day thawing during snow cover free periods during the fall and late spring. Surface instability can result (*congeliturbation*, Amundsen 1977) in disruption and downhill or lateral transport of soil particles hoisted on overnight formations of needle ice. When the needles collapse in the afternoon sun, attached soil materials are dropped and tend to *move* and/or become subject to subsequent water and wind erosion. A compromising suggestion might explain the rather intermediate TDS mean for Watershed 7. The tributaries tested in #7 are mostly north-south aligned streams with the west facing slopes getting the afternoon solar loading as they do along the upper Wood and Salmon River HWs, but the opposing east facing slopes support more closed montane forest stands and are positioned at a lower solar incident angle in the afternoon sun in both the spring and fall. Another possibility is the trapping (sequestering) of (dissolvable solid) soil materials in or beneath thick mor humus on the more completely forested east facing montane zone slopes resulting in lower TDS readings in exporting waters at the altitudes of the Biorefuges. A third consideration might be the slope surface disturbance and "walkdown" caused by summer ranging sheep and native grazers in forage stands. The walking trails are more noticeable on grazed west facing slopes. Basic pH readings from both east and west flowing streams do not change with TDS readings made simultaneously, remaining mostly the same (7++) in both instances.

COLIFORM TESTS

Coliform bacteria, a complex taxonomic class, are natural components of soils and waters. Most kinds are generally benign and some actually helpful in terms of human health. Within this group, often less benign *E. coli* bacterial strains live in the intestines of people and other warm blooded animals. Many such are generally harmless in a healthy intestinal tract. However, the very detection of waterborne coliform bacteria in numerous, potential Colony Forming Units (cfu), is widely accepted as warning for potential water contamination. Many kinds of bacteria are released in the feces of infected carriers and some are threats for disease (Consumer Guides, 2014).

A regular presence of defecating domestic and wild animals and careless sanitary behavior by humans active in or near the Biorefuge contact surface waters has suggested simple treated bag tests for coliforms in general with advanced plate incubations to quantify *E. coli* cfu.

Bluewater Biosciences (Bluewater, 2011, 2013) coliform test materials were (and are) used for water testing. As the company name implies, coliforms turn sampled waters blue when the materials are used. Developmental incubations can be carried out in the field without access to utility service but styrofoam chests were used for controlled temperature maintenance.

Waters showing obvious evidence of animal activity (scat) were tested across all seven of the designated watersheds. Samples in this test study were taken at about a 10 cm depth (when possible) away from the edge of the water and care was taken to avoid silt. C. L. Ball reports (Ball, 2011) that there is no critical sample taking location for bacterial collections from natural waters.

Bluewater Watercheck test bags for field sampling with protocols for qualified detection of coliform bacteria were used in 2012 and 2013. Bag test reagents indicate any coliform presence by the generation of blue colored water. For quantitative tests, *Bluewater Coliplates* were used. These plates, with discrete cells containing responsive nutrient concoctions, turn any coliform infected cells visibly blue allowing cell counts for cfu. The blue cell number translates into Most Probable Numbers (MPN), indicating the quantity of cfu's (of general coliforms) per 100 ml of sample water. Under long wave "black light" (here, a battery driven 383 nm flashlight) *E. coli* cells among the blue dyed cells which fluoresce indicate a proportional presence of *E. coli*. Table 2 summarizes these preliminary test results.

(Table 2.)

Watershed	Qualified Presence	Quantified	MPN	Fluorescing	MPN
#1, Sublette					
Camp Ground	**Yes**	15/96	43	**No**	
#2, Shoshone					
Lodge Pond	**Yes**	25/96	76	12	33
Faun Wallow	**Yes**	90/96	938	42	151
#3, WdRiv west draining, east facing slope					
N.Fk Wood@R75	**Yes**	35/96	114	**No**	
#4, WdRiv east draining, west facing slope					
Baker@R75	**Yes**	12/96	33	**No**	
#5, SlmnRiv west draining, east facing slope					
Pole Cr	**Yes**				
4th July Cr	**Yes**				
No coliplate tests. Watercheck bags positive for qualifying coliform presence, two streams					
#6, SlmnRiv east draining, west facing slope					
	Yes				
Pettit Lake Outlet. *Coliplate test aborted, likely heat of sun destroyed E.coli in sample. Watercheck bag positive for qualifying coliform*					
#7, SoFkBoiseRiv/Camas Front					
Big Smoky Cr@bCG	**Yes**	16/96	39	**No**	

Table 2. First Run Coliplate Tests 2013. Coliplate test runs were made in all seven Watershed units. **Yes** indicates coliform presence in tests, either by qualifying Watercheck bags or within quantifying Coliplate cells. Positive qualitative tests show blue colors. Fluorescence of blue cells allows quantifying Coliplate cellular count for *E. coli*. **No** indicates no *E. coli* detected in these tests with black light. Colony Forming Units (cfu) leading to Most Probable Numbers (MPN) discussed in text. Watershed #2 shows *E. coli* presence, but no other Coliplates showed fluorescence in these preliminary attempts. Local sample site names under Watershed divisions are for field note reference at this time.

As a general rule, any detection of *E. coli* disqualifies the sampled water for human consumption. The levels allowable for recreational water use vary with health agency jurisdictions but are generally at or below a 31 fluorescing cell count (of 96 cells in this procedure) with an equivalent MPN of 98 (less than 100 *E. coli* per 100 ml water).

Charles A. Lenkner, DVM, a colleague on the board of the Twin Falls County (ID) Pest Abatement District Board, has been involved in studies of *E. coli* O157:H7 in livestock dietary relationships (personal communication). He has asked the author if the *Coliplates* distinguish or combine *E. coli* strains. (Lenkner, 2013). The manufacturer, Bluewater, does not claim their tests earmark particular strains of this bacterium.

E. coli O157: H7 is the strain most commonly identified as causing coliform disease infections in North America. A major source of such infections is from

fecal contamination of water by cattle, although other warm blooded animals including humans and birds, may be involved. Cattle water troughs as well as nonbovine sources are known to be viable reservoirs of *E. coli* O157 (Lejeune et al., 2001). Dairy wastewater ponds in southern Idaho have also been shown to harbor bacterial indicators such as *E. coli*, as well as a number of zoonotic pathogens (Dungan, Klein and Leytem, 2012). Medical reports show over 250,000 human *E. coli* infections in the United States each year (Centers for Disease Control, 2012). Infections of pathogenic coliform strains can lead to other (esp. bovine) illnesses as well.

The *Coliplate* tests used in this study encompass the *E. coli* group, likely including those that are harmful. Above certain levels of responsive cfu presence and high MPN, these simple field tests indicate a need for more rigorous responsible agency analyses for particular pathogenic contaminants. The public accessing these waters should be made aware of these possibilities.

ADDENDUM

(INFORMATION ACQUIRED SINCE SUBMISSION AND REVIEW OF THIS PAPER)

During the summer of 2014 two pertinent references were sent to the author by colleagues. The first is the EPILOGUE from the publication Cattle in the Cold Desert (J.A.Young and B.Abbott Sparks) University of Nevada Press, 2002). Young and Abbott detail the value of native forage grasses which flourish where environmental conditions are favorable and enlightened grazing management practices are applied. The second is the article published in Freshwater Biology (2010) 55, D.M.Merritt et al., Theory, method and tools for determining environmental vegetarian: riparian vegetation-flow response guilds). This study links the productivity of native guilds to the water available to supporting soils.

The field season of 2014 featured rechecks of TDS in the seven watersheds distinguished for this continuing study. TDS measures continue to reflect the clustering of values that separate the chosen watersheds. Field tests for coliform bacteria were expanded in 2014 and showed consistent presence of general coliforms in all waters tested. Plate incubation tests reaffirmed the presence of E. coli in the waters (Watershed 2) where the organisms were found in 2013.

COMMENT AND ACKNOWLEDGEMENTS

Simple forage harvest clips and visual observations suggest higher forage productivity is linked to habitat conditions effected by intrusive waters higher in TDS. Nutrient presence often implied with dissolved solids were not separately identified although plant nutrient presence is likely. The perennial forage plant guilds characterize the valuable Biorefuge habitat producer food web resources. These desirable grass genera arrays have been identified as persistent in all seven watersheds. The adjacent surface waters, besides intrusively enhancing forage growth and sustaining subsurface decomposition processes, provide a necessary resource for many consumers. The continuation of these studies confirms empirical distinctions for the seven targeted watersheds based on repeated comparisons of TDS value means over 13 growing seasons. Criteria for

watershed separation based on TDS measure mean value clusters are supported by long-term observations of holistically considered landscape features and the use of recent geology maps.

The demonstrated presence of colifoms, especially the detection of *E. coli*, suggests the application of more sophisticated responsible agency tests beyond the capability of the portable field test protocols used here. Visual observations indicate an increasing number of family recreationists in the areas studied. This report will be offered to such agencies.

The intentions of this *Pro Bono* study are to provide a partial base line depiction of the valuable Biorefuge expressions which have the inherent, resilient capability of areal expansion or contraction with long term or even some erratic changes in climate. Such areal changes may be related to highland surface water resource conditions and/or to migratory alterations of biorefuge plant and supported animal communities as producer/consumer/predator components change.

The addition of field testing for coliform bacteria in the biorefuge supporting waters is perhaps indirectly tied to the prospective health and well being of consumers of the resources available as well as recreating visitors and certain downstream uses.

The author has received a good deal of assistance from many sources. I thank the anonymous reviewers of the first report published in 2011 and of this manuscript. The financial support of Dr. Miriam Austin and her Red Willow organization has allowed ongoing resupply and maintenance of field instruments and test supplies. C. A. Lenkner DVM has graciously critiqued pertinent sections of this manuscript in progress. The author is an “appreciated” volunteer ecologist for Region 4 of the US Forest Service.

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56TH ANNUAL SYMPOSIUM OF THE IDAHO ACADEMY OF SCIENCE: THEME: ENERGY, MATERIALS, AND NANOTECHNOLOGY

PECVD-Deposited Germanium Chalcogenide Films for use in Memory Devices

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Renewed interest in the use of germanium chalcogenide semiconductors for use in memory devices has been driven by their unique properties. They have very stable amorphous and crystalline phases, and the change in the electron conductance between the two phases can be several orders of magnitude. The degree of order in the amorphous phase appears to be largely localized, but the materials are unique; some longer range channels or island-to-island structure may exist as well. This substructure may be a function of the film stoichiometry and metal doping. These properties lend themselves well to the use of germanium chalcogenides in phase-memory, conductive-bridging RAM, and Resistive RAM devices.

In this study, PECVD of germanium chalcogenide thin films was done utilizing GeCl4, H2S, and alkyl chalcogenides. Their use for thin film deposition of this material was evaluated. The effect of reactor flow rate and plasma power on deposition rate, composition, and film morphology were determined. Based on these results, germanium chalcogenide thin films were deposited by PECVD in several stoichiometries, as thin layers in phase memory and resistive RAM devices. Results from the thin film studies and the use of these thin films in memory devices will be discussed.

Optical Phonon Properties of MgxZn1-xO Thin Film Alloys

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Jesse Huso, University of Idaho
Dinesh Thapa, University of Idaho
John Morrison, Lewis and Clark State College
Leah Bergman, University of Idaho

MgxZn1-xO thin film alloys with the Mg composition ranges from x=0 to x=0.78 were synthesized via reactive magnetron sputtering. Phase segregation occurs due to structural differences of the end members. Selective resonant Raman scattering was utilized to investigate the phase segregation range; 3.8 eV laser excitation detects an embedded Zn-rich hexagonal structure while 5.1 eV laser excitation detects an embedded Mg-rich defective cubic structure. The nature of the structural disorder in the alloys was studied via Urbach energy, obtained from optical absorption, and Raman spectral line broadening. The alloying compositional fluctuation was found to be the dominating mechanism of the structural disorder for MgxZn1-xO alloys at the phase segregation range.

CHRONIC MITOCHONDRIAL DNA-DELETION INDUCES CHANGE IN ACONITASE EXPRESSION AND PRODUCTION OF ROS IN DRG NEURONS

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Mitochondrial dysfunction resulting from mutations and/or deletion of mitochondrial DNA (mtDNA) has been implicated in many neurological/neurodegenerative diseases, including peripheral neuropathy. To investigate the effects of mtDNA depletion in peripheral neuropathy, we have developed a cell model with mtDNA deletion employing dorsal root ganglion (DRG) neurons, an important neural cell type in the peripheral nervous system. This study was initiated to test the hypothesis that mtDNA depletion induces disruption of communications between the nuclear and the mitochondrial genomes. Our results reveal that chronic mtDNA depletion in DRG neurons led to enhanced production of reactive oxygen species and decreases in the expression of aconitase, which catalyzes the conversion of citrate to isocitrate. Our findings provide partially support for several proposed mechanisms involved in peripheral neuropathy. Consequently, they may assume pathophysiological importance in peripheral neuropathy in particular and neurodegeneration in general.

Fe-based Nanoparticles and Their Applications in Nano-Nuclear Technology

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Key words: Magnetic properties, Reduction, Irradiation, Agglomeration.

Degradation of materials due to constant exposure of radiation and high temperatures has been a constant challenge for the current generation of nuclear reactors. Through Nano-Nuclear Technology, latest engineered-nano-materials are used for improving the nuclear power performances and safety. We investigate the radiation behavior of Fe-based nanoparticles by studying the structural, magnetic and electrical properties before and after irradiation. Fully oxidized Fe

nanoparticles like Fe_3O_4 and FeO have been found to alter the radiation effects and enhance radiation resistance. These iron oxide particles could be good candidates for studying the dispersion strengthening phenomena in nuclear materials as it promotes grain boundaries and interfacial effects. Moreover, Fe-based core-shell nanoclusters (NCs) with core as Fe and shell as Fe_3O_4 and core as Fe and shell as Fe_3O_4/Fe_3N have provided some interesting reduction behavior and unique magnetic property changes under irradiation. These core-shell nanomaterials and their unique behaviors could provide promising applications in the future generation nuclear reactors as sensors and monitors.

Magnetic Separation Nanotechnology for Water Remediation and Spent Nuclear Fuel Recycling

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The greater quantities of waste generation and the more stringent regulations for waste discharge/disposal call for a more effective and efficient treatment process to overcome the drawbacks existing in the traditional separation methods. Novel magnetic nanosorbent—surface functionalized magnetic nanoparticles conjugated with specific metal chelators—has been developed for separation of metal ions from aqueous systems, which offers a simple, fast, effective, and environmentally benign technique in wastewater treatment and spent nuclear separation. Our current study has coupled DTPA chelators to double coated magnetic nanoparticles (dMNPs). The batch sorption experiments have demonstrated that the dMNP-DTPA conjugates is an effective and excellent sorbent material for cadmium (Cd) and lead (Pb) adsorption. The sorption of Cd or Pb onto the dMNP-DTPA conjugates was fast which reached the equilibrium in 30 min. Desorption of metal ions and regeneration of the sorbents was achieved by 0.1 M HCl stripping, which showed that the dMNP-DTPA conjugates can be reused more than 10 sorption/desorption cycles without significant decrease in sorption efficiency. With a saturation magnetization of ~20 emu/g, dMNP-DTPA conjugates can be easily manipulated and separated from solution in less than 1 min by applying an external magnetic field with a field gradient of above 300 G/mm. The static magnetic separation results were used to validate the Computational Fluid Dynamic (CFD) simulations. With the help of CFD, a new magnetic separation system will be designed operating under continuous flow conditions. By tailoring the surface functionality of the magnetic nanosorbents, this kind of separation nanotechnology has also been applied for uranium or other valuable element recovery from spent nuclear waste.

Effect of yttria and alumina on the microstructure and mechanical properties of nickel-chromium based alloys

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There is a need to enhance high temperature properties of structural materials used in fossil-fuel-fired power plants for increasing their efficiency. The materials considered should have high temperature strength, creep resistance and corrosion resistance in the high pressure, corrosive environment. In this study, atomized Ni-20Cr powder was mechanically milled with Y_2O_3 nanoparticles to produce a dispersion-strengthened Ni-20Cr-1.2Y_2O_3 (wt.%) alloy powder, and subsequently Al_2O_3 particulates were added to form a composite powder, Ni-20Cr-1.2Y_2O_3-5Al_2O_3 (wt.%). Microstructural characteristics of the powder were studied using XRD, SEM/EDS and TEM. The ball milled powder was consolidated using spark plasma sintering (SPS) to produce bulk specimens with near full density. The developed materials were examined using the same analytical tools to study the microstructural features of the ball milled specimens. Mechanical properties of these specimens were evaluated using microhardness, and compression testing. Appropriate microstructure-properties correlations have been developed. The effect of Y_2O_3 addition on refining the grain size was clearly evident. The presence of homogeneously distributed nano dispersoids in a large volume fraction led to higher microhardness values and grain refinement in the Ni-20Cr-1.2Y_2O_3 alloy compared to Ni-20Cr alloy. Adding Al_2O_3 to Ni-20Cr-1.2Y_2O_3 could initiate the additional composite strengthening mechanism due to the larger size of Al_2O_3 particles.

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How Will We Power the Future? The case for more nuclear energy

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In the first half of the 19th Century, the approximately 1 billion inhabitants of planet Earth derived primary power from “renewable” wood, wind, water, and muscle power – civilization advanced and population grew. The second half of the 19th and the 20th Century was the age of fossil carbon discovery and exploitation during which 85-95% of primary power in the U.S. was provided by coal, oil, and gas. During this period, the developed world experienced tremendous technological growth and in general human longevity increased (despite two world wars), as did the global population base (3 billion in 1960). At the beginning of the 21st century, global population exceeds 7 billion. A somewhat more diverse mix of energy production options still includes 85% fossil carbon combustion

globally. Today, the prospects and potential impacts of climate change have spurred consideration of other options. In this presentation, the strengths and limitations of fission-based nuclear energy will be discussed and compared with the benefits and liabilities of other power production options.

A Single ZnO Coated Nanospring Chemiresistor

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A redox chemical sensor (chemiresistor) was constructed with a single ZnO coated silica nanospring. The chemiresistor response to toluene vapor as a function of the sensor temperature (T_{NS}) and vapor temperature (T_V) was observed and analyzed. During the experiment the maximum sensitivity of the single ZnO coated nanospring device was achieved at the sensor temperature (T_{NS}) being 310°C and at the vapor temperature (T_V) of 250°C. A comparison of the electrical response characteristics of a single ZnO coated nanospring device with those characteristics of a ZnO coated flat surface was conducted in order to demonstrate the influence of the chemiresistor geometry on the sensor sensitivity. A computational model was developed to simulate an electrical response of the hexagonal polycrystalline ZnO structures deposited on the substrates of different geometries.

IC Bond Pad Structures for Simulation using Finite Element Method

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IC bond pads must withstand the stress of probing at die sort, wirebonding during assembly, plastic molding during packaging, thermal cycles in board mount, and then the bond pads with their wirebonds are expected to perform reliably for many years in use. Previous finite element modeling (FEM) using IC bond pads have suffered because of insufficient detail in the bond pad layers and "circuitry". More realistic bond pad structural models are required in our ongoing reliability studies. Four-level metal bond pads developed so far include "traditional" aluminum (Al) metallization, with some variations such as "missing M3" and circuit under pad (CUP), and a structure having the metal layers separated into tiles for high flexibility in altering metal pattern densities. Bond pads in copper (Cu) metallization bond pads are also developed, relating to more modern IC processes. Though the bond pads may appear to be simple, the modeling becomes quite sophisticated when including options for changing layer thicknesses, allowing arbitrary placement of patterned holes in the metals, and adequately representing circuitry under pad (CUP) situations of interest in IC design. 3D modeling has worked best to replicate experimental data, though models in the literature have typically avoided the long computation times by using 2D. Some of our models have over 4000 individual parts, and all are constructed from multiple materials. Discovering optimal methods for meshing

the models to obtain detailed results in focus areas, while not going over the university license limit, is a continual challenge. Features of our models that have been advantageous are the ability to easily change film thicknesses, to assign different materials to parts of the individual layers to represent circuitry, and to easily select components for tighter mesh in an area of interest. The ability to simulate the full bond pad in 3D while under probing or bonding stress, and then "slice" the model in half for stress analysis is particularly useful, which comes as a benefit of the sophisticated FEM software.

This project is an example of how "real world" industrial problems can be introduced in an undergraduate teaching environment, challenging the students who have basic skills with FEM, enabling them to use their creativity in problem solving. Their successful models become the foundation models for further research by follow-on students. The complex bond pad models developed in this work have already been of use in other student research [1-3].

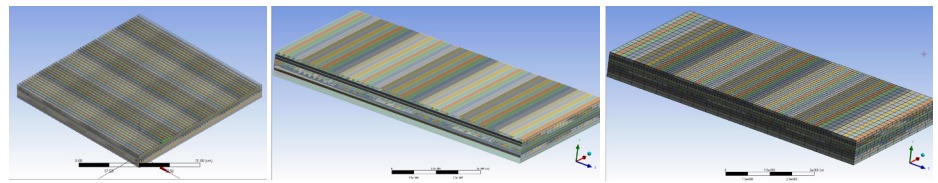

FIGURE 1 IC bond pad model example for an Al–SiO2 4-level metal. (Left) drawn solid model, (center) sliced model view as used in stress analysis, (right) slice view showing finite element "mesh", denser in the center In this case.

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Applications of Core-Shell Fe Magnetic Nanoparticles from Used Nuclear Fuel Recycling to Groundwater Remediation

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The unique properties of magnetic nanoparticles (MNPs), such as their extremely small size and high surface area to volume ratio, provide better

kinetics for extracting metal ions from aqueous solutions. Here we demonstrated the separation of minor actinides using complex conjugates of MNPs with diethylenetriamine-pentaacetic acid (DTPA) chelator. The sorption results show the strong affinity of DTPA towards Am (III) and Pu (IV) by extracting 97% and 80% of actinides, respectively. If these long-term heat generating actinides can be efficiently removed from the used fuel raffinates, the volume of material that can be placed in a given amount of repository space can be significantly increased. Fe/Fe-oxide MNPs synthesized in our laboratory have showed the enhanced reactivity towards targeted contaminants due to the presence of zero valent iron (ZVI) protected by a passivated oxide shell. Physical and chemical characteristics of the shell surrounding the metallic iron core are likely to play an important role in determining the chemical reaction pathway taken place during the breakdown of carbon tetrachloride (CT). Reactivity results show that 80% of the degradation of CT resulted in the formation of dichloromethane and chloroform; compared to 20% of reactivity for commercial ZVI.

Thermally Stimulated Luminescence Study in Preheated and X-irradiated Polyether Ether Ketone

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In this study, we have detected Thermally Stimulated Luminescence (TSL) in as-received and X-irradiated Polyether Ether Ketone (PEEK) film. TSL on preheated samples of PEEK film is obtained to know the effect of heat on this polymer. We reported thermoluminescence in PEEK (as-received and X-irradiated), which is done the first time to our knowledge. The non-irradiated PEEK exhibits a sharp glow peak at about 150°C, near glass transition temperature. The X-irradiated sample shows a distinct peak at 100°C along with the 150°C peak. Intensity of these peaks seems to increase with the irradiation dose.The observed new peaks at 100°C and the increase in its intensity with X-ray dose may be due to chain scission in PEEK polymer chain as a result of X- irradiation.

When non-irradiated PEEK samples were first preheated before TSL measurements at temperatures ranging from 50-150°C, no significant changes in the glow peaks were observed. However, the intensity of the glow curves decreased as a function of temperature in the interval 150-250°C, and disappeared when heated at or near 250°C. The primary 150°C glow peaks disappeared upon preheating at temperatures from 250°C to 341°C (near the melting temperature of PEEK), but then new thermoluminescence is detected at near 75°C of the TSL glow curve.

Key Words: Thermoluminescence, Glow curve, Chain scission.

Magnetic watermelon: Cr-doped core-shell Fe nanocluster

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We studied the nanostructure and magnetism by doping Cr into Iron/Iron-oxide core-shell nanoclusters (NCs) prepared by cluster deposition system at varied atomic percentages of Cr from 0 at.% to 8 at. %. The increase in coercive field and exchange bias field (Hex) has been reported below room temperature after the incorporation of Cr in the NCs. The formation of antiferromagnetic (AFM) Cr2O3 as a mixture with Fe-oxide shell causes the increase in Hex. The magnetic interactions in Fe NCs (~25 nm) can be controlled by AFM Cr-dopant. We report the origin of □-FeCr phase at very low Cr concentration (2 at. %) unlike in previous studies, and the interaction reversal from dipolar to exchange interaction in 8 at.% of Cr-doped core-shell NCs. With the inclusion of Cr in a core-shell system, □-FeCr originates as an intermetallic phase with bcc-Fe. The structural model of a Cr-doped core-shell NC looks like a watermelon, where the seeds of melon act like □-phase, spreading uniformly throughout the Fe-core (Fe pulp). The exchange coupling between the grains of □-FeCr and bcc-Fe at their grain boundaries play a significant role in controlling the net interaction.

Creating new light emission in the UV via alloying.

Leah Bergman, Department of Physics, University of Idaho

ZnO is emerging as one of the materials of choice for UV applications. It has a relatively benign chemical nature, a deep excitonic energy level, and a direct bandgap of ~ 3.4 eV. The latter two properties make ZnO a highly efficient light-emitter at room and above room temperatures. Alloying ZnO with certain atomic constituents can add new optical and electronic functionalities to ZnO. This work will focus on the $Mg_xZn_{1-x}O$ alloy where the x in the formula is the percent composition of the alloy constituents such that. Upon changing the composition, the bandgap and the optical properties can be tailored from these of one end member to the other. In principle, new materials can be grown with bandgaps ranging from that of ZnO, at 3.4 eV, up to the bandgap of MgO at ~ 7.0 eV. The talk will address topics that include phase segregation of the alloy constituents, phonon dynamics, and the characteristics of the light emissions.

This work is supported by the National Science Foundation Grant No. DMR-1202532

Enhancement of the UV photoluminescence of ZnO and MgZnO films via annealing

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ZnO and its alloy $Mg_{0.3}Zn_{0.7}$ O are excellent materials for UV emitters. ZnO and $Mg_{0.3}Zn_{0.7}$ O films were grown on sapphire substrate using a DC sputtering technique, and were post annealed under both Ar and O_2 gas atmospheres. Optical properties of the both as-grown and annealed films were investigated utilizing photoluminescence and transmission spectroscopy. The results of

these studies revealed that annealing under Ar at 900 °C results in an increased bandgap and enhanced UV photoluminescence (PL) in the ZnO film. Annealing under O_2 contributed to visible defect-related emissions in the film. PL spectra of the as-grown MgZnO film exhibited two UV peaks indicating the fluctuation of Mg content in the film. After O_2 annealing, the MgZnO continued to show two UV peaks as observed in as-grown film along with O_2 defect-related visible emission peak. However, PL spectra of Ar annealed MgZnO showed an enhanced single UV peak indicating that a completely homogenized alloyed film with enhanced optical properties has been achieved.

This research was supported by National Science Foundation Grant No. DMR-1202532

Advances in Film Characterization with QCM Devices

Nathan Wilkerson (G), University of Idaho
Dr. Mark Roll, University of Idaho

Quartz crystal microbalances (QCM) are a specialized subset of crystal oscillators used to determine properties of films applied to the quartz sensor surface. These properties are measured by examining the responses of the QCM system to various changes in the mass or thickness of the applied films or by deviations from the uncoated QCM behavior. Fine mass measurements can be accurately measured by measuring the change in the sensor's resonant frequency. The very basic relationship between film mass and frequency, known as the Sauerbrey equation, has proven useful in a number of applications and is currently finding resurgence in the biofilm area as a method for modeling colony growth and other micro-scale applications.

Though this sort of application has seen much interest, many of the electrical response characteristics are still poorly understood. Less attention has been given to measures such as raw voltage, current and impedance changes in the QCM. In particular it is fine voltage/current measurements that using precision, low impedance Superconducting Quantum Interference Devices. This experimentation is beings supplemented by a considerable array of multiphysics computer simulations to better illustrate any mechanical or electrical changes within the system and hopefully better understand this extremely useful analytical device.

Title: XPS Study of a Fischer-Tropsch Cobalt Catalyst Supported on Silica Nanosprings during Reduction

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The reduction of a silica nanospring (NS) supported cobalt catalyst for Fischer-Tropsch synthesis (FTS) has been monitored by X-ray photoelectron spectroscopy (XPS). The cobalt is present in the starting catalyst as a Co_3O_4 spinel phase. A two-step reduction of Co_3O_4 to CoO and then to Co^o is observed,

which is consistent with H_2-temperature programmed reduction (H_2-TPR). During the reduction the two steps are simultaneous. The deconvolution of the Co 2p core level state for the catalyst reduced at 385°C and 1.0×10^{-6} Torr of hydrogen after 63 hours revealed contributions from metallic cobalt, CoO, and Co_3O_4. The reduction saturates after 20 hours at a rate of 41.4%, which explains the decline recently observed in the activity of the catalyst during FTS tests. Conversely, at 680°C and 10 Torr, the catalyst is completely reduced. The presence of metallic cobalt is also evidenced by the appearance in the XPS valence band of an evolving Fermi edge.

SCHWANN CELLS MODULATE MANGANESE-INDUCED OXIDATIVE STRESS IN DRG NEURONS AND IMPART CYTOPROTECTION

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Manganese (Mn) is an essential micronutrient which regulates many physiologically important processes such as glucose metabolism and antioxidant defense. However, Mn induces toxicity when it is taken in excess. Our previous studies demonstrated that manganese induces neurodegeneration via induction of oxidative stress in neurotumor cells. However, how glial cells interact with neurons in modulating manganese-induced toxicity in non-tumor neural cell lines has not been elucidated. Therefore, we have developed co-culture models of cells derived from peripheral nervous system, namely dorsal root ganglion (DRG) neurons and Schwann cells to investigate the putative role of glial cells in protecting neurons from manganese-induced neurodegeneration. Results of our ongoing studies employing monotypic and co-cultures of DRG neurons and Schwann cells suggest Schwann cells modulate the oxidative stress induced by manganese in DRG neurons and associated signaling mechanisms, thereby exerting their neuroprotective effects. Thus, our results may assume pathophysiological importance in peripheral nerve degeneration and manganese-induced neurodegeneration.

Neutral Homoaromaticity - The Synthesis and Study of Some Annelated Semibullvalenes

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Most semibullvalenes (e.g., the parent 1) have localized ground states (1, 1') and undergo the Cope rearrangement via an aromatic transition state ($1^{\ddagger}$). A goal of our research is to convert this transition state to a homoaromatic ground state. Homoaromaticity results from the through space cyclic delocalization of 4n+2 electrons and imparts a "special" stability to the homoaromatic species. Examples of electrically charged homoaromatic species are well-known; however, until very recently there were no experimentally verified examples of neutral homoaromatic molecules. In the gas-phase, semibullvalene 2 was characterized as the first example of a neutral homoaromatic carbocycle and subsequently 1,3,5-cycloheptatriene was demonstrated to be homoaromatic in the condensed-phase. Through molecular orbital calculations, we predict that a range of annelated semibullvalenes (e.g., 3a, 3b, and 4) will be the first examples of condensed-phase homoaromatic semibullvalenes. We have prepared semibullvalenes 2a and 3 and investigated the nature of their ground states (localized or delocalized homoaromatic) by a variety of experimental techniques including a modified Saunders' isotopic perturbation method.

Use of GT-Suite to Study Performance Differences between Internal Combustion Engine (ICE) and Hybrid Electric Vehicles (HEV) Powertrains

M. Sh. Asfoor*, and S. Beyerlein**

Hybrid Electric Vehicles (HEVs) are receiving a great deal of interest around the world due to their promise of higher energy efficiency, reduced highway emissions, and also their ability to overcome the range limitations inherent in a purely electric automobile. In hybrids, chemical energy is stored as a petroleum fuel and in electrical energy is stored in a battery pack, and is converted to mechanical energy by an Internal Combustion Engine (ICE) and an Electric Motor (EM), respectively. The EM is used to improve energy efficiency and vehicle emissions while the ICE provides extended range capability.

Computer simulation is a valuable tool for analyzing hardware components and predicting vehicle performance. In this work an ICE vehicle is compared to several hybrid versions, modeled using GT-Suite. A variety of standard driving cycles are considered, among them The Federal Test Procedure (FTP) for city driving, and the Highway Fuel Economy Test (HWY). This study considers a rule-based energy management strategy for power splitting in the hybrid models. ICE only and hybrid modes are compared based on average as well as instantaneous performance. The overall energy consumption and fuel economy were monitored. Model results demonstrate reduced fuel consumption and improved low-speed acceleration.

Bio-Jet Fuel: Environmental Implications of Woody Biomass Harvest

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The renewable energy policy of the United States sets time and quantity targets for the production of renewable energy, including bio-fuels. The recent development of a commercial processes for producing high-density liquid fuel from woody biomass has motivated millions of dollars of grant research and development projects and the enthusiastic support from the wood products industry as well as both commercial airlines and military fleet operations. Eager to demonstrate reductions in carbon emissions the government and airlines emphasize the environmental benefit of substituting a portion of petroleum-based fuel with a reduced CO_2 emission substitute. This paper presents a literature review of the environmental implications of harvesting woody biomass for bio-fuel production. The environmental issues considered include CO_2 emissions but also issues of impacts on several categories of forest organisms and wildlife, stream hydrology, forest restoration after harvest, and forest health issues related to thinning, wildfires, harvest of burned trees and forests killed by beetle infestations.

Idaho's Rejuvenation of the Nuclear Industry

Blacker, Paul; INL (Retired)

Idaho is uniquely able to rejuvenate the nuclear industry because it alone has the necessary advantages for such an achievement. These advantages will be described in the presentation.

Accomplishing these bold objectives will require strong leadership from the Governor, our congressional delegation, in addition to Idaho's scientific, industrial, educational, and commerce leaders. Only a united and sustained effort can drive Idaho's new leadership in nuclear programs.

Idaho can acquire the necessary concessions partly by leveraging the Federal government's unilateral cancelation of the Yucca Mountain repository. Concessions include:

1) All nuclear funding goes to the Lead Nuclear Laboratory and its affiliated universities.

2) A commercial nuclear facility must be built in Idaho by 2030. Several different options are possible.

3) Residual wastes stranded in Idaho receive top priority remediation and long-term storage at INL because of cancelation of Yucca Mt. repository is Federal repudiation of the Batt 2035 agreement.

4) Long-term, above ground, storage facility for commercial spent fuel should be built at INL, pending satisfactory completion of a full-scale spent fuel repository.

The benefits to a scientific, educational, and economic stimulation from Idaho's nuclear leadership are huge.

The effect of proline cistrans isomerization on p53MDM2 binding

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Proline is unique in that it is the only amino acid that adopts both cis and trans conformations in proteins. In spite of the importance of proline isomerization as a molecular switch in proteins, the effect on protein binding has not been thoroughly investigated, especially for intrinsically disordered proteins (IDPs). In this study, a potential of mean force method was used to calculate the absolute binding affinities for the disordered p53 and MDM2 when the proline in p53 is in both cis and trans conformations. To obtain converged affinity results it was necessary to apply conformational, axial, and orientational restraints to the protein internal coordinates. Our results give insight into how isomerization of a proline affects binding of an IDP to a structured protein.

In-situ TEM observation inspired material designing concept for rechargeable battery

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Lithium ion batteries are powering essentially our everyday electronics such as cell phones, laptops, cameras, tools, and electrical cars, and potentially stationary storage. However, there are some fundamental challenges that need to be addressed for these applications, typically such as capacity, power rate, cycle life, and safe operation. A range of materials has a high theoretical capacity, while in reality, this type of materials cannot be used directly due to a fast capacity fade. The capacity fading and short cycle life of the battery using this type of materials are directly related to the overall large volume expansion. In this presentation, I will discuss the fundamental challenges and possible ways for attacking these obstacles. In particular, I will review some of the general nanoscale designing concepts for tailoring composite materials based on silicon and carbon as anode materials for high capacity and long cycle life. Furthermore, I will also review recent progress on the development of in-situ TEM capabilities for probing the structural evolution of both anode and cathode materials for lithium ion battery.

Collective buckling Behavior of CNT Turfs

Hamid Torabi, Harish Radhkrishnan, Sinisa Dj. Mesarovic

Complex structures consisting of intertwined, nominally vertical carbon nanotubes (CNTs), grown from a substrate, are called turfs. These turfs have promising electrical, thermal and mechanical properties for use in applications such as contact thermal switches. These properties are controlled by the details of the turf microstructures. Under uniform compression experiments CNT turfs exhibit permanent collective buckling of a layer preceded by reorientation of CNT segments. The buckling length is controlled by the nanostructural parameters of the turf which are the turf density, connectivity, and tortuosity (average curvature). In this study, we develop a discrete computational model to simulate the collective buckling of CNT turfs and investigate the relationship between the macroscopic material properties, including the buckling length and nanostructural

parameters under uniform loads. The model is based on the representation of CNT segments as elastica finite element. The initial turf configuration is generated by means of the restricted random walk algorithm and subsequent relaxation. The van der Waals forces between adjacent tubes are modeled as distributed loads. The resulting computational model is robust and is capable of modeling the collective behavior of CNTs.

Co-Culturing Novel Euglena with Environmental Microbes

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Euglena are photosynthetic protozoa that synthesize ω-3 and ω-6 polyunsaturated fatty acids making them potential sources for nutritional supplements and biodiesel production. To that end we have isolated regional Euglenids and selected one for its ability to withstand long-term storage. Nuclear 18S rRNA and chloroplast 16S rRNA sequences suggest a novel species temporarily named Euglena species G12. Because G12 thrived in storage with a mixed microbial consortium, we reasoned that one or more of these microbes provided essential nutrients. To test this hypothesis, 10 phenotypically distinct microbes were isolated from the G12 storage medium. To investigate possible symbiotic relationships, the microbes were co-cultured individually or in pair-wise combinations with G12 in a minimal medium that did not favor growth when species were grown individually. Both G12 and a number of the microbial strains grew faster and were stable for longer periods when grown together. Two bacterial strains, however, also strongly stimulated G12 swimming, an activity that mimics normal environmental behavior. Co-culturing Euglena or green algae with such stabilizing microbes is an attractive alternative to pure culture approaches.

Detection of cancer biomarker EGFR using modified electrodes

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The quest to identify and detect early onset of cancer and genetic diseases has been greatly enhanced by the development of biosensors targeted at biomarkers that are directly related to specific cancers. One such versatile biomarker is epithelial growth factor receptor (EGFR). Over expression of EGFR gene has been identified as an indicator of the presence of cancer such as breast, non-small-cell lung cancer, colon and pancreatic cancer. EGFR is over

expressed in 20-30% of breast cancer tumors.

This report reviews the latest innovation in the use of electrochemical detection of EGFR with highly modified biosensor electrode. Clinical detection limits of 5.17 ng/mL have been reported using commercial test kit while lower detection limits of 1 – 100 pg/mL have been reported using antigen-antibody modified electrodes. These electrode biosensors are label-free, detect in real-time and invaluable in point of care diagnostics.

Our research team has successfully developed ultra-sensitive electrodes with bio-composites consisting of polymer layers, gold nanoparticles and biomolecules for detection of biomarkers such as HIgG (Human immunoglobulin G) and PSA (Prostate-Specific Antigen) with limit of detection lower than 10^{-16} g/mL. A similar approach can be employed for the detection of EGFR. Results of the detection of these proteins/enzymes are explored and potential of applications are discussed.

Key words: EGFR, bio-composite, nanoparticle, cancer, antibody, sensor

Experiences in Online Teaching and Research with Undergrad Engineering Students

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This paper highlights some of my experiences in teaching electrical engineering students while transitioning from traditional university teaching to online course teaching. Most aspects of online teaching are appealing to both students and adjuncts like myself, who have a different “day job”. In fact I couldn’t teach at 2 universities while working full time, without the convenience of online methods. However, on a new course, I suffer from having to spend a horrendous amount of time in preparation. Students suffer from never being together with their classmates. It’s possible to conduct a meaningful “virtual workshop” with the students, but I can’t bring the lab to them. Assessing true student learning, and concerns about cheating are among the difficulties I face. My experiences with remote undergraduate students doing volunteer research are interesting as well.

In this presentation I’ll discuss pros and cons, issues, and some practical ideas from my experience, for achieving best engineering learning while making use of the easily available technologies.

Polyoxometalate Cores In Hybrid Nano-Building Blocks for Extreme Ultra Violet Photoresists

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Dr. Mark Roll, University of Idaho

Extreme Ultra Violet (EUV) lithography is a developing semiconductor fabrication technology of great potential. The Semiconductor Research Consortium has provided support to investigate a hinderance in the progression of this technology: the need for photoresists that can polymerize at EUV wavelengths in the range of 13.5 nm.

Polymer based chemically amplified photoresists have historically been used with great success but are limited in the EUV range. Polyoxometalate Nano-Building Blocks offer the potential to serve as non-chemically amplified photoresists with higher resolution, favorable EUV absorption, and negligible off-gassing. Photoresists of this type would provide the precision and flexibility required in the next generations of semiconductor devices.

The polyoxometalate project begins with synthesis of tetrabutylammonium isopolyoxometalates. A hexamolybdate structure of this type has been successfully synthesized and confirmed through single-crystal x-ray diffraction. The hexatungstate variant is under current examination. From these isopolyoxometalates, it is planned to generate a polymerizable organic/inorganic molecule that can then be polymerized as a photoresist.

Following the resist synthesis, characterization will need to be performed to determine photoresist suitability. Facilities at the National Institute of Standards and Technology, the University of Idaho, the University of Wisconsin, and industry partners will be utilized in the evaluation process.

Flipping a Non-majors’ Biology Class: Using Video Lectures, Online Resources, and a Student Response System to Facilitate Deeper Learning.

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Using pre-recorded video lectures, online resources, and a student response system (iClicker), instructors at the College of Southern Idaho attempted to facilitate deeper learning in a non-major’s biology class. Following an inverted classroom format, students viewed lecture videos and completed online activities prior to face-to-face meetings with instructors. During face-to-face (traditional “lecture”) time, instructors tested student knowledge and guided students in group activities. Using a quasi-experimental design, researchers compared student performance on a comprehensive final exam with student performance from a previous semester. An independent sample t test indicated that students engaged in the inverted instructional model ($N = 73$, $M = 74.49$, $SD = 12.54$) performed better than students engaged in a traditionally model of instruction ($N = 76$, $M = 70.32$, $SD = 12.19$), $t(147) = -2.06$, $p = 0.02$. The effect size for this analysis ($d = 0.02$) represents a small effect according to Cohen (1988). Researchers also performed a chi-square test of goodness-of-fit to determine if grades distributions from the inverted model differed from the traditional model. Grade distributions from the inverted model were significantly different, X_2 (5, N=100) = 24.85, $p < .05$. Of note, instructors using the inverted pedagogy allocated time very differently than in a traditional biology lecture. Instructors allocated 52% of the face-to-face class time for interactive/group activities, 25% of the time for testing, 15% of the time for instructor lecturing, and 8% of the time for administrative tasks

(establishing groups, making announcements, organizing questions).

Targeting of DNA by Invader probes: tools for exposing and manipulating the genome

Dale Guenther, Saswata Karmakar, Brooke Anderson, Patrick J. Hrdlicka
University of Idaho

Targeting of double stranded DNA (dsDNA) is an exceedingly interesting challenge due to advances in genome sequencing and the desire to understand how this code dictates cellular function. Access to dsDNA would provide a facile and reliable way to modulate or characterize any gene in living cells and open the door for a variety of gene therapy and diagnostic approaches. This has been an ongoing challenge of molecular biologists, with few approaches emerging, such as peptide nucleic acids (PNA), triplex forming oligonucleotides (TFO), minor groove binding polyamides, and engineered proteins. These suffer from limitations such as the requirement of non-physiological conditions, sequence restrictions, or significant synthetic challenges. The Hrdlicka group developed Invader probes as a novel approach for targeting of dsDNA. These nucleic acid probes contain modifications that force intercalation of aromatic moieties into close proximity, thus destabilizing the Inavder probe duplex. When the recognition event occurs, however, dramatic increases in the stability of the corresponding duplexes are observed. Efficient and specific targeting of dsDNA by Invader probes has been demonstrated towards cell-free hairpin DNA and genomic DNA in non-denaturing fluorescence in situ hybridization (nd-FISH).

Silsesquioxane Hybrid Nano-Building Blocks for Improved Photoresists in Semiconductor Technology

Brandon Hardie, University of Idaho
Dr. Mark Roll, University of Idaho

The development and characterization of octa-silsesquioxane (POSS) hybrid nano-building blocks shows great potential for the improvement of semiconductor devices. The first objective in this Semiconductor Research Corporation-funded research is the synthesis of POSS-based macromolecules with both vinyl and benzocyclobutenyl functional groups. Following this, new resist formulations will be developed and optimum spin coating demonstrated. This will lead to the photoresist evaluation for EUVL—a technique in lithography utilizing extremely low wavelengths (~13.5nm)—which will be completed using facilities at the National Institute of Standards and Technology to determine processing parameters for development and etching that maximize resolution. Expected improvements in this field include improved resolution, sensitivity, image stability, and negligible off-gassing and tunable EUV absorption.

Currently, synthesis of the precursor silicate octa-anion has been done in bulk for the production of POSS macromolecules in high yields. From this precursor, the desired “vinyl”-POSS was developed as well as a trimethyl-POSS for practice of standard procedures. Further efforts in the immediate future include developing resists from the POSS structures for spin coating tests. In addition to spin coating, contrast curves for the resists will be obtained utilizing SEM prior to final characteristic evaluations to be done at NIST and industry partners.

Investigating the Role of Lysosomal Membrane Permeabilization in Cadmium-induced Apoptosis in Osteoblast-like Cells

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Cadmium is a heavy metal released into the environment primarily through the improper disposal of electronic waste. Human exposure to cadmium is linked to the development of bone diseases such as osteoporosis. Our lab researches mechanisms by which cadmium induces apoptosis in bone-forming osteoblasts. One under-investigated area of osteoblast apoptotic signaling is the involvement of lysosomes. We hypothesize that cadmium induces lysosomes to permeabilize, release cathepsins, leading to apoptosis in osteoblast-like cells Saos-2 and MG-63. Cells were treated with 0-10 μM $CdCl_2$ for 24 or 48 hours. Lysosomal permeabilization was visualized using Acridine Orange and lysosomal protease cathepsin b expression was determined using Western blot. $CdCl_2$ treated cells were co-treated or pre-treated with cathepsin b inhibitor CA074Me and viability was assessed using MTT assay. Acridine Orange and MTT results suggest that cadmium does not induce lysosomal permeabilization as a cell death mechanism. Western blot analysis suggests that cadmium induces cathepsin b expression, indicating induced autophagy in osteoblasts. This work furthers understanding of cadmium’s effect on lysosomal function and its induced toxicity in bone.

A Teaching Approach at the Biology-Organic Chemistry Interface

Dinara Storfer, University of Idaho

Teaching fundamentals of organic chemistry to life science majors is a challenging task. Chemistry and life science disciplines are fundamentally different. Whereas chemistry is a physical science for which phenomena are governed by formulated physical laws that are mathematically deducible, biological sciences are frequently governed by stochastic events.

An approach that merges the two disciplines pedagogically is needed. A successful approach to teaching at the biology-organic chemistry interface necessitates inclusion of physics and biology concepts. For example, a biological organism is an extraordinary physical system that constantly exchanges energy and matter with the environment to stay “alive” by maintaining thermodynamic non-equilibrium. However, non-living organic matter is a physical system that is in a natural state of thermodynamic equilibrium.

The exchange of energy and matter happens through organic chemical reactions. The physical law that governs all organic chemical reactions is charge transfer. Charge transfer is the unified premise that teaches life science students to understand organic chemistry principles and their relationship to biological life.

Title. Synthesis and Electrochemical Properties of GUITAR: A Breakthrough Material for Energy Storage.

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Abstract. In the search for a low cost and simple method for graphene synthesis, a closely related material, GUITAR (graphenic/graphitic material from the University of Idaho Thermolyzed Asphalt Reaction) was discovered. The synthetic method is inexpensive, simple, rapid and low temperature (600 - 800 ^{0}C). It does not require a crystalline template. Starting materials include any organic with boiling and melting points between 80 to 180 ^{0}C and sulfur, either in its elemental form or as a compound. Other starting materials have including roofing tars, and food products. GUITAR and highly ordered pyrolytic graphite (HOPG) have similar visual characteristics in that both are flat and have layered 2-D morphologies. Both HOPG and GUITAR have metallic appearances. However, AFM and SEM images along with Raman indicate that GUITAR has microscopic differences with HOPG. Raman spectroscopy indicates that the grains are nanocrystalline (La = 5 nm) as indicated by the D and G bands at 1354 and 1594 cm^{-1} respectively and I_D/I_G = 0.93. Electrochemical results indicate stark differences between HOPG and GUITAR. The unique properties of GUITAR include (i) fast heterogeneous electron transfer with dissolved redox species (ii) very high aqueous anodic and cathodic stabilities and (iii) high capacitances per unit area. In 1 M H_2SO_4 the anodic and cathodic limits are 2.0 to -1.0 V, a potential window of 3 volts, much larger than the 2 volts with HOPG. The electron transfer rate constant of 0.01 cm/s for the $Fe(CN)_6^{4-/3-}$ redox couple is 4-6 orders of magnitude greater than HOPG. The capacitance per unit area ranges from 100 to 700 □F/cm^2 in 1 M H_2SO_4 depending on fabrication process. Other materials produce less than 10 □F/cm^2. We hypothesize that the combination of these features indicate that GUITAR may be a new allotrope of carbon. We will also discuss proposed applications which include water purification, ultracapacitors and redox flow batteries. In terms of ultracapacitors GUITAR may improve performance ($E = ½ CV^2$) over present materials by 2 orders of magnitude.

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A Specific HPLC-UV and Fluorescence Method for the Detection of Three Anti-Depressant Drugs in Various Water Systems

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Pharmaceuticals in water are considered as a major emerging pollutant because of their ubiquity in the aquatic environment and their health effects. A new, fast and economical HPLC method was developed for the analysis of carbamazepine, venlafaxine and fluoxetine in water systems.

A gradient reverse-phase HPLC assay was used with UV and fluorescence detectors. Sample was passed through Gemini C18 110A (250 x 4.60 mm, 5 µm, Phenomenex) column at a flow rate of 1.0 ml/min. A mixture of citric acid and EDTA was mixed in water and was used as a solvent A. Mobile phase was made by mixing solvent A and methanol. 4L of water samples were collected and separated by solid-phase extraction procedure, using the (Oasis HLB, 30 µm) cartridges on a Vac Elut apparatus and an HPLC run was performed.

From spiking experiments, limit of detection (LODs) and limit of quantification (LOQs) for carbamazepine were 10 ng/l and 100 ng/l, for venlafaxine were 1 μg/l and 1 ng/l, and for fluoxetine were 100 ng/l and 1 μg/l, respectively.

HPLC can be used to detect the trace amount of pharmaceuticals in water. The technique requires no derivatization steps, requires less time and is more cost-effective.

Regulation of and Spatial Variation in Biomarkers Indicative of Contaminant Exposure in Signal Crayfish (*Pacifastacus leniusculus*) Inhabiting the Boise River, Idaho

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Aquatic ecosystems are susceptible to pollution which can adversely affect organisms inhabiting impacted areas. It is therefore important to determine whether organisms exhibit biological responses to contaminant inputs. In this study, we examined acetylcholinesterase (ACHE) activity in tail muscle and metallothionein (MT) concentrations in gill tissue in signal crayfish exposed to the organophosphate pesticide dimethoate (0.3, 0.6, 0.9 mg/kg) and the metal zinc

chloride (0.6, 0.9, 1.2 mg/kg) as well as in crayfish collected from sites along the Boise River with varying land use practices taking place in the surrounding areas.

ACHE activity was significantly inhibited in tail muscle at all concentrations of dimethoate tested relative to a saline control. However, neither ACHE nor MT changed in response to $ZnCl_2$. ACHE activity and MT concentrations varied in crayfish collected from sites located downstream of urban and agricultural areas.

Phase I and II detoxification enzyme activities as well as superoxide dismutase activity were also detectable in signal crayfish tissues, although the regulation of these enzymes by contaminants still needs to be characterized. Further testing is needed to examine the regulation of these biomarkers in signal crayfish to determine whether they are sensitive bioindicators of pollution.

Chemical analysis of historic artifacts from the Market Street Chinatown in San Jose

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A prosperous Chinatown in the center of San Jose, CA, was destroyed by arson fire in 1887. Numerous artifacts were recovered in an excavation carried out in 1985 and placed in storage. Recently, archaeologists at Stanford University have worked on this collection, and a number of artifacts were sent to the University of Idaho Chemistry Department for chemical analysis. Among the materials analyzed were Chinese “stone drugs” – folk medicines derived from natural minerals since ancient times. Other items included treated wood fragments from the remnants of a dwelling, and everyday objects that originated in Anglo-Saxon America. Due to the sudden nature of the destruction of this Chinatown, many bottles and containers that were recovered still had their original contents.

Fast removal of heavy metals from contaminated water using magnetic separation nanotechnology

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Abstract: Removing heavy metals to reach the regulation limits is always an urgent and hot issue in wastewater treatment. Greater quantities of wastewater generation call for a faster heavy metal removal process. In light of magnetic separation technique and nanotechnology, a new sorbent material, dMNP-DTPA conjugates - diethylene triamine pentaacetic acid (DTPA) molecules coupled to double coated iron magnetic nanoparticles (dMNP) – has been synthesized and assessed in metal batch sorption experiments. The results confirmed that this novel magnetic nanosorbent offers a simple, fast and effective method for separation of cadmium (Cd) and lead (Pb) ions from aqueous solutions. The sorption of Cd or Pb on the sorbents conformed to the pseudo-second-order-reaction mechanism and the Langmuir isotherm model. The calculated sorption capacity were 8.06 mg/g for Cd and 12.09 mg/g for Pb. Via the study of the effects of contact time, pH and initial metal concentration, the optimum conditions required for maximum metal sorption were determined.

A Review of Research on Student Learning with Implications for Teaching College Science

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The purpose of this manuscript is to review research from the fields of biology, education, psychology, and others regarding how students learn and then to use this research to propose a contemporary approach to teaching college science. Scholars have devoted considerable time to ideas such as how students learn and what constitutes best practices in education. However no clear consensus exists regarding a specific model for teaching generally, or for teaching college science specifically. Perhaps the complexities of individuals and institutions will never allow such a consensus but that does not pardon educators from striving to find a model that works for most students in most situations. I have reviewed research on how students learn and how faculty teach their courses and discuss the implications for teaching college science. I conclude with a framework for curriculum development and a call for novel approaches that address our changing understanding of how students learn.

Keywords: learning, research, college, teaching, science

Six of one, a half-dozen of the other: does a student-centered instructional model positively influence course satisfaction and content knowledge?

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College of Western Idaho

The purpose of this paper is to describe a model for teaching introductory biology coursework at a primarily undergraduate institution. The intent of the new model was to transform my instruction from information transmission by me to information acquisition by students. I begin by describing what I refer to as the cartwheel model which is based on best practices in science education. I then provide examples of active, inquiry-based, and student-centered teaching tools that I’ve used with the cartwheel in two undergraduate biology courses. Students’ end-of-course evaluations, final exam scores, and grade distributions are used to compare the cartwheel to a traditional lecture model of instruction. Results from both courses over 16 months of teaching demonstrate that student-centered instruction is superior to traditional lecture in terms of student satisfaction and the percentage of completers that earn a failing grade. However student achievement, in terms of final exam scores and grade distributions, are not different between the

two models of instruction leaving one to question the value of student-centered instruction. I finish by discussing the implications of the present study and suggesting recommendations for advancing science education research.

Influence of Ni dopant on structural, vibrational and tribological characteristics of synthetic Magnesium Hydrosilicate.

Pavlo Rudenko, Washington State University
Nikolay Frik, Duke University
Qiuying Chang, Beijing Jaotong Univerisity

:

There has been an emerging interest in use of nano particles of magnesium hydrosilicates as film forming tribological compounds for energy efficiency and industrial machinery life time extension. Additional benefit is clean nature of the materials which can lead to formulation of clean lubricants. We previously reported remarkable performance achieved in our exploratory study that excite curiosity toward mechanism of a film formation that is currently poorly understood.

Here we report variation in structural, vibrational and tribological characteristics of magnesium hydrosilicates with lizardite structure from ab-initio simulations and their correlation with measured data (XRD, FTIR, SEM, TEM, DSC/DTA, Tribometry). Such information helps to develop a model on tribological behavior and tailor performance of MHS for energy applications.

Regulation of Inflammatory Cytokine-Promoted Tumorigenesis and Metastasis

Jennifer R. Leggett-Lidgard, Danielle S. Hedeen, and Cheryl L. Jorcyk,
Boise State University

The American Cancer Society estimates 1.7 million new cancer diagnoses in 2014 in the United States alone. The World Health Organization has calculated an estimated an increase in cancer related deaths to 13.5 million worldwide by the year 2030. Breast cancer remains one of the most prevalent malignancies facing women today. It is estimated that there will be over 230,000 new incidents of invasive breast cancer in the United States in 2014 (with more than 1,000 cases occurring among Idaho women), as well as greater than 40,000 breast cancer related deaths (nearly 200 of which will transpire in the state of Idaho). Most cancer deaths are attributable to lack of effective treatment in the prevention of metastasis. While researchers have made great strides in the treatment of cancer, targeted research in the effective prevention of metastasis must continue.

Numerous studies have implicated inflammatory cytokines (proteins that normally help promote inflammation) in the promotion of cancer tumorigenesis and metastasis, though the mechanism of action is not well understood. We will present in vitro data on the regulation of pro-inflammatory cytokines by enzyme-linked immunosorbent assay (ELISA) in breast cancer cell lines (MCF-7, MCF-10A, MDA-MD-231, and T47D), prostate cancer cell lines (DU145 and PC3), as well as a cervical cancer cell line (HeLa). Illumination of molecular mechanisms promoting tumorigenesis could lead to the development of novel target therapies effective in the treatment and prevention of breast cancer metastasis.

Synthesis of polymeric precursors for refractory carbides and borides

Natalie Kirch, University of Idaho
Dr. Mark Roll, University of Idaho

Hafnium Carbide and diboride are ceramics with ultra-high melting temperatures representing the upper end of refractory materials. Current standard syntheses of these ceramics form powders in an energy intensive carbo- (boro-) thermal reduction or coatings via vapor deposition, a time consuming process requiring high vacuum conditions. Under the support of the Office of Naval Research work is being done towards an alternative by thermally decomposing preceramic polymers, such as polycarbynes and “polyborynes”.

Higher atomic weights and a polymer network rather than a chain structure eases the conversion from amorphous polymer to dense ceramic. For synthesis of polycarbynes, studies on Wurtz coupling of sp3 coordinated bromoform initiated with alkali metals have been published, but these reactions are extremely exothermic and potentially violent.

In an effort to reduce the hazards, the reaction set up was first modified to an electrochemical cell, and then to control the reaction rate with ultrasonic vibrations. The active metals used were alloys of sodium and potassium deposited in porous silica gel.

Work towards the “polyboryne” precursor will follow a similar reaction pathway to polycarbyne synthesis. Titanium will be used as a representative to hafnium as it is more stable for laboratory conditions.

Effect of desferrioxamine B on uranyl(VI) speciation in the presence of amidoxime ligands

Adetayo M. Mustapha: University of Idaho
Sofie P. Pasilis: University of Idaho

Amidoxime-based polymeric resins that can extract uranium from seawater are currently being developed and tested in the United States and Japan. Amidoxime-based resins are used because amidoxime groups have a high affinity for uranium at the pH of seawater. However, effective methods to extract uranium from the sorbent are still being developed. Naturally-occurring, environmentally-friendly organic ligands with high affinities for uranyl(VI), such as citrate or desferrioxamine B, could potentially be used to strip uranium from the amidoxime-based sorbent at pH ~4-8. We have used electrospray ionization mass spectrometry to examine complex formation between uranyl(VI) and two amidoxime ligands thought to be the main functional groups involved in uranyl(VI) complexation in the amidoxime-based resins used for uranium sorption: 2,6-dihydroxyiminopiperidine (DHIP) and N^1, N^5-dihydroxypentadimidamide (DHPD). We also evaluated the potential use of desferrioxamine B as a stripping agent by examining its effect on uranyl(VI) speciation in the presence of DHIP and DHPD. Our results show that uranyl(VI) forms 1:1, 1:2, and 2:3 uranyl(VI):ligand

complexes with both DHIP and DHPD. The stepwise addition of desferrioxamine B to a solution containing uranyl(VI) and DHIP led to a continuous decrease in the intensities of peaks assigned to uranyl(VI)-DHIP species. The decrease in intensity was pH dependent.

Positrons in Microtraps with Long Aspect Ratios: Trap Simulation and Fabrication

Alireza Narimannezhad, Joshah Jennings, Marc H. Weber, and Kelvin G. Lynn
Washington State University

The positrons storage capacity of micro-Penning-Malmberg traps with large length to radius aspect ratios and radii of the order of tens of microns was explored. The new design of the trap consisted of an array of microtraps with substantially lower end electrodes potential. Simulation studies were conducted with WARP Particle-In-Cell code. It was shown that each microtrap with 50µm radius, immersed in a 7T uniform magnetic field, stored positrons with a density of 1.6×10^{11} cm^{-3} while the confinement voltage was only 10V. The charge clouds developed the expected radial soft edge density distribution and rigid rotation evolved to some extent.

The fabrication of large length to radius aspect ratio (1000:1) microtrap arrays involved deep reactive ion etching (DRIE) of silicon wafers to achieve through-vias. Smoothing the sidewalls through oxidation and chemical etching prior to gold sputtering ensured a complete coating during gold sputtering. Gold-coated wafers were then aligned and thermal compression bonded using an aligner jig. Positron confinement time depends on trap imperfections. We present the fabrication issues encountered and address geometry errors and asymmetries.

Utilization of Cu6Sn5 Nanoparticles as Anodes in Sodium- Ion Batteries

Riley Parrish, Boise State University

Cu6Sn5 nanoparticles are being studied as an anode material for sodium-ion batteries. Sodium electrochemically alloys with tin, with an optimal composition of $Na_{3.75}Sn$ (theoretical capacity: 516 mAh g^{-1}). Copper is electrochemically inactive in sodium systems and instead acts as a buffer shell to surround the NaSn alloy for better electrical conductivity. In order to test the electrochemical performance of the copper-tin alloy, two processing techniques were used to fabricate the electrodes. The first technique utilizes vacuum filtration to create a free standing, flexible, binder free electrode by encasing the nanoparticles in a conductive multi-walled carbon nanotube (MWCNT) network. The second technique creates a laminated electrode cast on an aluminum current collector, combined with an electronically conductive carbon additive and a binding agent. These electrodes were tested using Na half cells, utilizing pure sodium metal as the counter electrode. Initial testing using the first technique shows promising initial capacity of approximately 120 mAh g^{-1}, but rapidly declines to below 60 mAh g^{-1} within 100 cycles. Studies on various additives, binders, and electrolytes are currently underway to improve the performance of the cells.

Nanotoxicity of CdSe Quantum Dots on Peripheral Nerve Cells

Briana M. Lindberg[1], Wenjuan Gao[2], James C.K. Lai[3], Solomon W. Leung[4]
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Semiconductor nanocrystals, also known as quantum dots are a non-traditional semiconductor with unique size-dependent properties that are of great interest across many industries. Researchers are exploring their applications in many fields such as optoelectronic and photovoltaic devices, optical amplifier media, probing, and imaging. With such explosion of application research, however, the effect of these nanocrystals to human health and the environment is essential unknown; the guideline of safety handling and disposal is non-existing.

In this study, we are attempting to establish the baseline toxicity of one of the most common semiconductor nanocrystals, CdSe quantum dots (QDs), on the peripheral nerve system by employing the QDs directly on the dorsal root ganglia (DRG) neurons of rats. Observations of cell morphology and MTT colorimetric assay are the procedures of toxicity evaluation.

Key words: quantum dots, MTT, DRG neuron, toxicity

Anatomy in Clay, a new approach for teaching anatomy to undergraduate students

Corey Riding, Department of Life Sciences, College of Western Idaho

Traditional anatomy instruction has relied on the dissection, prosection, and vivisection of specimens because they offer several benefits. For example, laboratory dissection allows a kinesthetic approach to group work and the opportunity to examine anatomical variation among individuals. However, use of cadavers – whether human or animal – carries increasing logistical, financial, and ethical burdens. Many science educators have turned to technology and alternative materials to complement or replace traditional instruction. One such methodology for anatomy instruction is the use of clay. Building clay structures onto a mannequin provides many of the same benefits as dissection with reduced ethical and long-term financial costs. I am offering scientists and educators, whether or not they have training in anatomy, the opportunity to experience building some anatomical structures with modeling clay.

CFD Analysis of Wind Turbine Blade Tower Interaction

Sean Quallen, Dept. of Mechanical Engineering, University of Idaho
Tao Xing, Dept. of Mechanical Engineering, University of Idaho

Each of the blades of a horizontal axis wind turbine (HAWT) passes the tower once per rotor revolution. This blade tower interaction (BTI) causes a disruption of the blade's aerodynamics resulting in power loss and vibrations. Wind turbine technology progress over the past several decades has led to the development of lighter, more flexible materials and significantly longer blades in the pursuit of higher efficiency. An understanding of the physics of the BTI will help in furthering this technology. Previous studies have focused mostly on downwind rotor HAWT whereas the upwind rotor HAWT is far more commonly used in service.

This study looks to investigate the upwind rotor BTI by performing computational fluid dynamics (CFD) simulations on the National Renewable Energy Laboratory's Phase VI test HAWT. Parametric studies of the effects of key design parameters – including wind velocity, blade pitch angle, and rotor rotational speed – are investigated and validated against experimental data. These same parametric studies are then repeated using a tower-less wind turbine rotor, possible only in computer simulations. Differences in aerodynamic characteristics and trends between these two configurations are presented. Potential design improvements based on these results, as well as future work, are also discussed.

Stroop Effect and Emergent Readers

Kaleigh Gehring, Highland High School
Samuel Weeks, Highland High School

The Stroop Effect is a test of visual perception and response. Many variations of this test have been used to explore differences based on gender and age and to better understand how humans process visual input. We have been working with variations of the Stroop test for the past two years. This year our research seeks to add to the body of knowledge about this topic by looking specifically at emergent and proficient readers. We could not find any studies relating to our question and feel that it is important as another piece of the human puzzle. If there are statistically significant differences between emergent and proficient readers we have a new clue about how/when we acquire symbolic language. Our preliminary results show that emergent readers show no statistically significant difference in their response times for color as compared to response time for word, while proficient readers do show a statistically significant difference. This supports our hypothesis that emergent readers would be more familiar with colors than words and would be less distracted by words written in different colors.

Van de Graaff based Positron Source Production

K. R. Lund, K. G. Lynn, M. H. Webber, M. A. Khamechi, J. Jennings. J. K. Eilers, C. Minimal, B. Riley, C. Baker.

The anti-matter counterpart to the electron, the positron, can be used for a myriad of different scientific research projects. Ranging from biomedical sciences, surface and materials defects, and energy storage for deep space flight, positrons hold the potential to advance mankind to new heights in technological achievement. At Washington State University, a 3MV Van de Graaff electro static particle accelerator was used to induce the nuclear reaction $^{12}C(d,n)^{13}N$. ^{13}N is an isotope of nitrogen that decays with a 10min half life into ^{13}C, a positron, and an electron neutrino. This radioactive gas is frozen onto a cryogenic freezer where it is then channeled to form an anti-matter beam. The beam is then guided using axial magnetic fields into a superconducting magnetic ranging up to 7T where it will be stored in a newly designed micro-Penning-Malberg trap. Several geometries for the beam source have been tested. A maximum anti-matter beam of greater than 50kcps was achieved. A new geometry, currently under development, will produce a beam 100 times greater. Current geometries and beam diagnostics will be discussed as well as the future for positrons as viable energy source.

Water Quality Testing in Rural Idaho

Fallon Horrocks, Highland High School
Jeremy Snodderly, Highland High School

Our research looks at water quality in north-central Idaho. The state and federal government are already studying surface water in Idaho for mercury contamination but none of the study sites are within a 50 mile radius of our community. We believe this may be in part due to the fact that we live in a very sparsely populated section of the state and are not located near any major recreational areas. Our concern is that many of the families in our area rely on surface water and shallow wells for the majority of their water needs including drinking, washing, irrigating, and stock. It has been difficult to collect our samples due to the early onset of winter conditions which have limited our access. In addition, we have not yet developed a reliable protocol for mercury testing but are continuing to work on both of these issues.

Cytotoxic effects of silver and gold nanoparticles in human glioblastoma U87 cells

Wenjuan Gao[1], Solomon W. Leung[1], Alok Bhushan[2] and James C.K. Lai[3]
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[2]Department of Pharmaceutical Sciences, Jefferson School of Pharmacy, Thomas Jefferson University, Philadelphia, PA 19107
[3]Department of Biomedical & Pharmaceutical Sciences, College of Pharmacy, Division of Health Sciences, Idaho State University, Pocatello, ID 83209

Silver and gold nanoparticles have gained particular interest in cancer nanobiotechnology because of their desirable qualities. Glioblastoma is the most common and highest grade primary brain tumors in adults. Despite some recent improvement in the treatment of this neurotumor, the prognosis of patients with this tumor remains extremely poor. In this study, we have investigated the

hypothesis that silver and gold nanoparticles exert differential cytotoxic effects on human astrocytoma (glioblastoma) U87 cells and silver nanoparticles are more cytotoxic than gold nanoparticles. Our results show that both silver and gold nanoparticles induced time- and concentration-related decreases in the survival of U87 cells. Consistent with our hypothesis, the effects induced by silver nanoparticles were much more pronounced than those of gold nanoparticles. Both types of nanoparticles also induced changes in the morphology of U87 cells, the effects of silver nanoparticles being the more marked. Thus, our results may have pathophysiological implications in cytotoxicity of metallic nanoparticles in neural cells and suggest silver nanoparticles may have chemotherapeutic potential in the design of new treatment(s) for glioblastoma.

Keywords: cytotoxicity, silver and gold nanoparticles, human glioblastoma U87 cells

The effects of cadmium on type I collagen in the extracellular matrix of osteoblast-like Saos-2 cells.

Dannen D. Wright, The College of Idaho
Sara J. Heggland, The College of Idaho

Exposure to cadmium is linked to the development of bone diseases such as osteoporosis. The mechanism by which cadmium leads to these diseases remains unclear. One possibility is that cadmium interferes with collagen in bone ECM. We hypothesize that cadmium binds collagen directly and interferes with collagen fibril assembly in the ECM produced by osteoblasts. Cell-free assays were utilized to investigate binding interactions between cadmium and type I collagen. Cell viability and collagen deposition were assessed in cell culture studies using Saos-2 cells induced to mineralize and treated with or without cadmium. Results indicate cadmium binds to type I collagen with a higher affinity than calcium and alters collagen fibrillogenesis. Cadmium exposure leads to condensed type I collagen distribution in ECM of cultured Saos-2 cells, possibly due to altered fibrillogenesis. Preliminary in vivo studies indicate significant bone pathology in rats treated with 12 weeks of cadmium. These studies will help elucidate the mechanism by which cadmium exposure can lead to bone diseases and ultimately aid in our fight against them.

IAS Award Program

NOMINATIONS ARE NOW BEING ACCEPTED FOR THE 2014 AWARDS.

The Idaho Academy of Science seeks nominations for three prestigious annual awards:

DISTINGUISHED SCIENTIST/ENGINEER

An individual with outstanding achievements in science or engineering.

DISTINGUISHED SCIENCE COMMUNICATOR

An individual with outstanding achievements in communicating the meaning and values of science to students and/or the general public.

OUTSTANDING NEW INVESTIGATOR AWARD—NEW FOR 2010

An individual who has begun his or her career in Idaho within the last five years, and has demonstrated great promise in science or engineering. The winner of this award is invited to give a keynote lecture at the symposium.

REQUIREMENTS AND ELIGIBILITY

Nominees' work should be conducted in or related to the state of Idaho. That means the person may live and work in Idaho or the work that he/she has done is of specific value or interest to Idahoans. Nominees need not be members of the Idaho Academy of Science or even professional scientists so long as their accomplishments are clearly scientific or in the realm of science education. Generally, nominees must be living at the time of the nomination . . . only in truly exceptional cases would the Academy consider giving an award posthumously. Other than these conditions, any individual who has contributed substantially to science/engineering or to science communication is eligible for one of these awards.

Submit nominations (electronically or 4 copies please) to the IAS Award Program Coordinator at:

Carol E. Blackburn
IAS Awards Program
330 E. 520 N
Shoshone, ID 83352-5216

NOMINATION PROCEDURES

Nominations must be typed and submitted electronically or in quadruplicate (four copies). All should include the following information:

- Nominee's name, address, phone number, and e-mail address.
- Nominee's occupation/title and institutional or company affiliation (if applicable).
- A summary of the accomplishments for which the person is to be recognized (about 250 words).
- A brief biographical sketch of the nominee, including educational and professional career information.
- The nominator's name, address, phone number, and e-mail address.
- At least one seconding letter in support of the nomination, more are preferable.

But the core of the nomination is:

- A detailed description of what makes the nominee worthy of an Award.

In no more than three or four typed pages, the nominee's accomplishments should be described in broad terms, with a statement of why the work is considered outstanding. Just enough key details should be included to support the case being made. This supporting description will vary depending upon the Award and, to some extent, the nature of the nominee's accomplishments.

Nominations for Distinguished Scientist/Engineer or Outstanding New Investigator should focus on the breakthrough qualities of his or her accomplishments. Typically, this would include a discussion of pioneering discoveries, seminal investigations, major innovations, and so on . . . always with a brief statement of why these are considered to be landmark achievements. Evidence of leadership - numerous citations of his or her publications, widespread follow-on work by others, service on technical committees and advisory groups, etc. - would do much to support the nominations. It is acceptable to include a full list of publications and patents in the nomination package, but a better approach would be to show only the most important papers and simply state the total number the nominee has to his or her credit.

Nominations for Distinguished Communicator could well cite innovation and inventiveness, but they are also likely to focus on effectiveness, impact, and influence. Outstanding achievers in education devise innovative classroom or field exercises and programs, create new and better ways to present scientific materials, find fresh ways to reach out to more students . . . they do whatever it takes to effectively convey the facts and concepts of science, and an appreciation for the scientific enterprise. Of course, providing "hard evidence" for the value of some of these accomplishments may be difficult. Sometimes the work may result in the publication of a manual, a conference paper, news articles, or even a textbook; but such opportunities are generally relatively limited. Supporting the nomination with additional "testimonials" may be the best way to show effectiveness and impact . . . but supporters should be urged to be as specific as possible. Comparable factors would also apply to other communicators - article writers, TV or movie producers, radio commentators, and so on.

They too will be judged on their effectiveness, impact, and influence. In these cases, the nomination might describe how a local series of "hit" science programs was picked up by the national media and broadcast all over the country. Perhaps a book with a science/technical theme by an Idaho author suddenly becomes a national bestseller. Maybe a lecturer from Idaho starts turning up on national public television, or becomes a "hot item" on the national lecture circuit. Such accomplishments could well qualify an individual for this award.

SUBMISSION INFORMATION

Completed nomination packages should be submitted by February 27th 2015 to the IAS Award Program Coordinator at:

R. E. "Gene" Stuffle,
Professor and Chair [Gene.Stuffle@isu.edu]
Department of Electrical Engineering
Idaho State University
921 S. 8th Avenue, MS 8060
Pocatello, ID 83209-8060

Nominations will remain active for a period of two years; after that, the nomination package would need to be revised and re-submitted. Additional supporting information may be submitted for addition to a nomination that is already one year old.

SELECTION PROCESS

Nominations will be reviewed by an ad hoc panel of at least three individuals, selected by the Academy President and Executive Director. If at all possible, the group will include individuals whose work areas correspond to those of the nominees. That is, if nominees represent chemistry, science education, and civil engineering, then the panel should have representatives from each of those fields.

The panel will review all the nominations versus the criteria outlines above and makes a formal recommendation to the Executive Committee. The final decision on whether there will be an award, and to whom, will be made by the Executive Committee. The President will then contact the person(s) selected to make sure he or she will actually attend the Annual Meeting or have to accept the award in absentia.

PAST RECIPIENTS

Recipients of the two awards in 2000 were:

Distinguished Scientist - Dr. Jerry D. Christian of Idaho Falls for an outstanding career of pioneering scientific research and leadership bringing recognition to Idaho science with national and international impact. His research focused on aqueous fluoride chemistry pertinent to processing irradiated nuclear fuels at the INEEL.

Dr. Jerry D. Christian

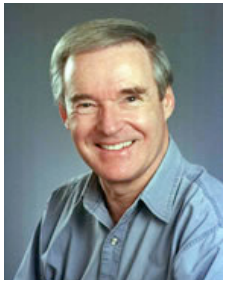
Distinguished Science Communicator - Dr. Russell J. Centanni, Professor of Biology at Boise State University for outstanding performance and dedication to furthering science education in the state of Idaho especially in communicating health issues ranging from HIV/AIDS to food-borne illnesses.

Dr. Russell J. Centanni

Recipients of the two awards in 2001 were:

Distinguished Scientist - Dr. Jean'ne M. Shreeve, University of Idaho for her internationally recognized research in fluorine chemistry, and for her effective research leadership as a board member of ACS and AAAS, as Idaho EPSCoR project director, and in graduate education at the University of Idaho.

Dr. Jean'ne M. Shreeve



Distinguished Science Communicator - Dr. Richard J. McCloskey, Professor of Biology at Boise State University for outstanding performance and dedication to furthering science education in the state of Idaho.

Dr. Richard J. McCloskey

Recipients of the two awards in 2002 were:

Distinguished Scientist - Prof. Donald M. McEligot of the Idaho National Engineering and Environmental Laboratory for his pioneering experiments and analyses in convective thermal fluid physics and for his technical leadership in developing the World's largest Matched-Index-of-Refraction system to study complex flow phenomena.

Prof. Donald M. McEligot

Distinguished Science Communicator Award - Ms. Susan M. Stacy of Boise for illuminating Idaho's rich scientific heritage, for exposing the human face of the scientific enterprise, and for recognizing that non-scientists are one of science's most important audiences.

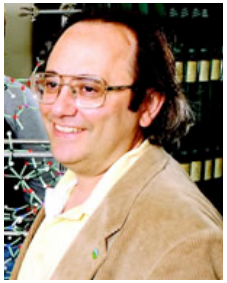
Ms. Susan M. Stacy

No awards were presented in 2003.

Recipients of the two awards in 2004 were:

Distinguished Scientist/Engineer - Dr. Richard D. Boardman of the Idaho National Engineering and Environmental Laboratory for exceptional leadership and innovative applications of science and engineering principles to develop and implement practical science-based solutions to unique environmental discharge problems of national importance and impact.

Dr. Richard D. Boardman



Distinguished Science Communicator Award - Dr. Nicholas R. Natale of the University of Idaho for his outstanding contributions to furthering chemical education nationwide, especially for his ability to communicate the science of chemistry through everyday experiences.

Dr. Nicholas R. Natale

Recipients of the two awards in 2005 were:

Distinguished Scientist/Engineer - Dr. Michael B. Laskowski of the University of Idaho for outstanding accomplishments in research and exceptional leadership and innovation in furthering biomedical research and industry in Idaho.

Dr. Michael B. Laskowski

Distinguished Science Communicator Award - Ms. Rebecca A. Thorne-Ferrel of the Idaho Museum of Natural History at Idaho State University for outstanding dedication and accomplishments in the field of science education and communication.

Ms. Rebecca A. Thorne-Ferrel

Recipients of the two awards in 2006 were:

Distinguished Scientist/Engineer - Dr. Joseph G. Cloud of the University of Idaho for pioneering research on the reproductive biology and conservation of salmonids, and broad ranging contributions to higher education in Idaho.

Dr. Joseph G. Cloud

Distinguished Science Communicator Award - Dr. Malcolm M. Renfrew of the University of Idaho for being eminently talented as chemist, educator, and friend, and continuing to advance quality and safety in science education and research in Idaho and around the world.

Dr. Malcolm M. Renfrew

Recipients of the two awards in 2007 were:

Distinguished Scientist / Engineer - Dr. Carolyn Hovde Bohach of the University of Idaho for her internationally recognized research on microbial pathogenesis and her leadership of biomedical research in the state of Idaho.

Dr. Carolyn Hovde Bohach

Distinguished Science Communicator Award - Dr. Steven L. Shropshire of Idaho State University for his outstanding efforts at effectively communicating the excitement of physics among science teachers and students in Idaho and throughout the United States.

Dr. Steven L. Shropshire

Recipients of the two awards in 2008 were:

Distinguished Scientist / Engineer - Dr. Eric Yensen of the College of Idaho for his accomplished career studying the taxonomy, distribution, and conservation of ground squirrels and for research on other North and South American mammals.

Dr. Eric Yensen

Distinguished Science Communicator Award - Dr. Rod R. Seeley of Idaho State University for his encouragement of students to think critically by using information to solve problems.

Dr. Rod R. Seeley

No awards were presented in 2009.

Recipients of the awards in 2010 were:

Distinguished Scientist / Engineer - Dr. Lawrence H. Johnston of the University of Idaho for his work in the early development of radar, invention of the exploding bridge wire detonator and service to his country as a member of the Manhattan Project, his definitive work on proton-proton scattering and the development of particle accelerators, research on the stark spectrum of Methyl Alcohol, and a long, distinguished career of research and education at the University of Idaho.

Dr. Lawrence H. Johnston

Distinguished Science Communicator Award - Dr. W. Daniel Edwards of the University of Idaho for a fabulously successful program of communicating the science of Chemistry through the medium of Art. Inside and outside the classroom, Dr. Edwards communicates his vast insights into the chemistry of art tohis students and to the population at large. In this way he has been able to bring Chemistry to many people who would otherwise never be exposed to it.

Dr. W. Daniel Edwards

The first recipient of the Outstanding New Investigator Award – Dr. Joseph.S. Gardner of the College of Southern Idaho for his part in the formation of alloy nanoparticles containing CuInGaS2 where the ratio of In to Ga can be changed to suit a particular application. He was instrumental in making nanoparticles, whose band gaps could be tuned through both size and composition control. His work at Idaho State University has promise to greatly further the use of these materials for enhanced-efficiency solar cells.

Dr. Joseph Gardner

Recipients of the two awards in 2011 were:

Outstanding New Investigator Award Recipient:
Kristen Mitchell, Ph.D., Boise State University
Dr. Kristen Mitchell received a B.S. in Microbiology from Idaho State University and a Ph.D. in Pharmacology and Toxicology from Washington State University. As a graduate student, she investigated mechanisms by which exposure to the environmental contaminant 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD or dioxin) suppresses the immune system. One of her major findings was that TCDD exposure suppressed the proliferation of antigen-specific CD8+ T cells. This led directly to her interest in TCDD-induced dysregulation of cell cycle progression.

Dr. Kristen Mitchell

Distinguished Scientist Award Recipient: Herbert D. G. Maschner, Ph.D., Idaho State University
Dr. Herbert Maschner is Research Professor of Anthropology, Interim Director and Curator / Division Head of Anthropology at the Idaho Museum of Natural History (IMNH), Director of the Center for Archaeology, Materials, and Applied Spectroscopy (CAMAS), Senior Scientist at the Idaho Accelerator Center (IAC), Head of Graduate Studies in the Department of Anthropology, Associate Editor of the *Journal of World Prehistory*, and an Executive Director of the Foundation for Archaeological Research and Environmental Studies (FARES). In 2006, he was named ISU's Distinguished Researcher. Maschner received his Ph.D. at the University of California-Santa Barbara, M.S. at the University of Alaska, and B.S. at the University of New Mexico.

Dr. Herbert Maschner

Idaho Academy of Science

IAS Enrollment/Renewal Form

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* William H. Baker Student Award Fund

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NOTES

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