Regular Board Meeting Agenda

Tuesday, September 15, 2026 | 6:00 PM | District Office Board Room, 8176 N. Westover, Joseph City, AZ 86032

Items on the regular meeting agenda may be discussed in executive session related to employment matters, for the purpose of obtaining legal advice thereon or other matters pursuant to A.R.S. 38-431.03(A). The Governing Board may change the order of agenda items, pursuant to Governing Board Policy BEDB. The meeting room will be open to the public fifteen minutes prior to the beginning of the meeting.

1. **OPENING ITEMS**
    - 1.A. **Call to Order**
    - 1.B. **Roll Call**
    - 1.C. **Pledge of Allegiance**
    - 1.D. **Invocation**
2. **APPROVE AGENDA**
3. **APPROVE MINUTES**

August 11, 2026 Regular Board Meeting
August 25, 2026 Special Board Meeting

Minutes of Regular Board Meeting of the Governing Board
Joseph City Unified School District
District Office Board Room, 8176 N. Westover, Joseph City, AZ 86032
Tuesday, August 11, 2026

Members present
Eldon Larsen, President; Dayton Flake, Clerk; Karsten Flake, Lexi Nelson

Administrators present
Shannon Harvilla, Superintendent; Caleb Layden, Business Manager; Eric Miller, JH/HS Principal; Pamela Dean, Elementary Principal

Others present
17 Community members

1. OPENING ITEMS

1.A. Call to Order
Motion by Eldon Larsen to call the regular meeting to order.
Time: 6:02 p.m.

1.B. Roll Call

1.C. Pledge of Allegiance

1.D. Invocation

2. APPROVE AGENDA
Motion by Eldon Larsen to approve the agenda with the following changes to agenda item 8A: 8A 1, Dominik Flake, Volunteer, and 8A2, Sharon Spurlock, JH Assistant Softball Coach; second by Dayton Flake
Final Resolution: Motion passed.
Yes: Eldon Larsen, Dayton Flake, Karsten Flake, Lexi Nelson

3. APPROVE MINUTES
July 14, 2026 Regular Board Meeting
July 22, 2026 Special Board Meeting
July 24, 2026 Special Board Meeting

Motion to approve minutes from July 14, 2026 Regular Board Meeting, July 22, 2026 Special Board Meeting, July 24, 2026 Special Board Meeting; second by Lexi Nelson
Final Resolution: Motion passed.
Yes: Eldon Larsen, Dayton Flake, Karsten Flake, Lexi Nelson

4. SUPERINTENDENT'S REPORT

5. REQUESTS TO SPEAK TO THE GOVERNING BOARD
Kelly Metzger, Box Tops for Education
Adriane Bushman, Appreciation for School Safety procedures

6. CONSENT AGENDA

Motion by Eldon Larsen to approve the Consent Agenda, Items 6A – 6F; second by Dayton Flake
Final Resolution: Motion passed.
Yes: Eldon Larsen, Dayton Flake, Karsten Flake, Lexi Nelson

6.A. Approve Expense Vouchers

Action to ratify district vouchers for the period 7/01/2026 through 7/31/2026.
General and Special Funds: #24 $160,005.54; #25 $164,668.16; #26 $373,621.43; #7 $83,473.19; #1039 $44,623.15; #1040 $21,880.74; #1041 $78,183.17; #1042 $76,291.74
Auxiliary Operations Funds: #1078 $3,761.81; #1082 $240.00; #1083 $442.00; #1088 $2,901.81
Student Activities Fund: #1080 $300.00; #1084 $7,432.25; #1085 $300.00; #1087 $500.51

6.B. Student Activities Fund Report

Revenues, expenditures and charges in the Student Activities Fund Report; period of 7/1/2026 through 7/31/2026.

6.C. Student Fundraisers

Organization	Description	Action
HS Football	Football Camp	Ratify
HS Cheerleaders	Selling Ads	Ratify

6.D. Gifts & Donations

Donor	Item	School/Program	Purpose	Amount
GoPowerSports	6 98cc engines	Auto Program	Hands on Experience	$1320.00
Harbor Freight	$100	Auto Program	Supplies	$100
Blattner Energy	School Supplies	School-wide	Class Supplies	approx. $500

6.E. Approve Qualified Evaluators for Certified Staff

6.F. Disposal of Surplus Property

Approve the disposal of unused surplus furniture, equipment, books, vehicles and other items in compliance with Arizona statutes and administrative code via our online auction web service.

7. POSSIBLE EXECUTIVE SESSION (*)

None

8. ACTION ITEMS

8.A. Personnel Requests (*)

Name	Assignment	Action
Bowler, Laurie	Chess Club Sponsor	Renewal
Bowler, Laurie	Class Sponsor	Renewal
Bowler, Laurie	NCA Chairperson	Renewal
Bowler, Laurie	National Honor Society Sponsor	Renewal
Brawley, Gianna	Student Worker	Renewal
Brawley, Micah	Class Sponsor	Renewal
Brawley, Micah	Skills USA	Renewal
Bushman, Brayden	Student Worker	Renewal
Bushman, Dan	Graduation Coordinator	Renewal
Bushman, Dan	CTE Director	Renewal

Bushman, Jess	Class Sponsor	Renewal
Deets, Trenton	Student Worker	Renewal
Delgado, Christian	Student Worker	Renewal
Edwards, Jeri	Class Sponsor	Renewal
Edwards, Jeri	JH Student Council Advisor	Appointment
Fischer, Brad	Class Sponsor	Renewal
Fischer, Rosemary	Student Worker	Renewal
Gayer, Michael	Chess Club Sponsor	Renewal
Gayer, Michael	Class Sponsor	Renewal
Gardner, Justin	Student Worker	Renewal
Hansen, Kylie	Student Worker	Renewal
Hansen, MariJoe	Class Sponsor	Renewal
Hutchens, Dan	Class Sponsor	Renewal
Hutchens, Daniel III	Auditorium Coordinator	Assignment
Isaacson, Taura	Class Sponsor	Renewal
Johnstun, Aaron	Class Sponsor	Renewal
Larsen, Trina	Class Sponsor	Renewal
Larsen, Trina	FFA Assistant Sponsor	Renewal
Miller, Kylie	Class Sponsor	Renewal
Miller, Paxton	Student Worker	Renewal
Mosier, Darrel	Volunteer	Acceptance
Neal, Lillian	Class Sponsor	Renewal
Nez, Kalebrinta	Student Worker	Renewal
Pedersen, Jordan	Auditorium Worker	Renewal
Petersen, Wylie	Student Worker	Renewal
Peterson, Amy	Class Sponsor	Renewal
Peterson, Amy	Concession Stand Supervisor	Assignment
Peterson, Amy	FBLA Sponsor	Assignment
Peterson, Amy	Red Ribbon Coordinator	Renewal
Rael, Dimitrios	Student Worker	Renewal
Rael, Synali	Student Worker	Renewal
Rush, Kay	Class Sponsor	Renewal
Sander, JJ	Student Worker	Renewal
Smith, Tyson	Class Sponsor	Renewal
Smith, Tyson	Hot Rod Club Advisor	Renewal
Smith, Tyson	Skills USA	Renewal
Sorgen, Ed	Concession Stand Supervisor	Renewal
Spurlock, Gina	Substitute Bus Driver	Appointment
Varney, Jean	JH/HS Volunteer	Acceptance
Westover, Jennifer	HS Student Council Advisor	Renewal

Whetten, Jason	Drama Coach	Renewal

Motion by Eldon Larsen to approve 8.A. personnel as presented; second by Lexi Nelson
Final Resolution: Motion approved.
Yes: Eldon Larsen, Dayton Flake, Karsten Flake, Lexi Nelson

8.A.1

Flake, Dominik	Volunteer	Acceptance

Motion by Eldon Larsen to approve 8.A.1. personnel as presented; second by Lexi Nelson
Final Resolution: Motion approved.
Yes: Eldon Larsen, Karsten Flake, Lexi Nelson
Abstained: Dayton Flake

8.A.2

Spurlock, Sharon	JH Assistant Softball Coach	Ratify

Motion by Karsten Flake to approve 8.A.2. personnel as presented; second by Lexi Nelson
Final Resolution: Motion approved.
Yes: Dayton Flake, Karsten Flake, Lexi Nelson
Abstained: Eldon Larsen

8.B. Appoint a Delegate to represent the JCUSD Governing Board at the ASBA Delegate Assembly.
Consideration and possible action to appoint a delegate and alternate to represent JCUSD as the district delegate to the Arizona School Board's Association delegate assembly to be held on September 12, 2026.

Motion by Eldon Larsen to nominate Lexi Nelson as delegate to represent JCUSD at the ASBA Assembly with Eldon Larsen as alternate; second by Dayton Flake
Final Resolution: Motion passed.
Yes: Eldon Larsen, Dayton Flake, Karsten Flake, Lexi Nelson

8.C. A Resolution of the Governing Board of Joseph City Unified School District No.2 Authorizing and Requesting an Advance of Basic State Aid from the Arizona Department of Education pursuant to A.R.S. § 15-973(C)
A Resolution of the Governing Board of Joseph City Unified School District No.2 Discussion and possible action to approve Resolution No. 2026-50 Authorizing a Request for an Advance of Basic State Aid from the Arizona Department of Education pursuant to A.R.S. § 15-973(C)

Motion by Eldon Larsen to approve Resolution No. 2026-50 Authorizing a Request for an Advance of Basic State Aid from the Arizona Department of Education pursuant to A.R.S. § 15-973(C); second by Karsten Flake
Final Resolution: Motion passed
Yes: Eldon Larsen, Dayton Flake, Karsten Flake, Lexi Nelson

8.D. A Resolution Authorizing and Requesting a Revolving Line of Credit through the Navajo County Treasurer. Effective beginning Fiscal Year 2026-2027
Discussion and Possible Action to Authorize and Request a Revolving Line of Credit through the Navajo County Treasurer for Fiscal Year 2026-27 in an Amount not to Exceed $2,600,000., Pursuant to A.R.S. §11-604.01.

Motion by Eldon Larsen to Authorize and Request a Revolving Line of Credit through the Navajo County Treasurer for Fiscal Year 2026-27 in an Amount not to Exceed $2,600,000., Pursuant to A.R.S. §11-604.01.; second by Karsten Flake
Final Resolution: Motion passed
Yes: Eldon Larsen, Dayton Flake, Karsten Flake, Lexi Nelson

9. INFORMATION ITEMS

None

9.A. Review of Possible Policy Changes to be Considered for Adoption at a Future Meeting PA 1047-1064

See the attached Policy Advisory for policy changes to be considered. See the Link section of this agenda item to view the current policy manual. No policy changes will be adopted at this meeting. Policies affected BEBD, CBA, DJ, DJE, IHA, IHB-R, IKE-RB, IKF, JF-R, JFAA-R, JFAB-R, JFABC-R, JFABD-RB, JFABDA-RB, New Regulation JFB_RB, JJAB, Regulation JR-R, KFA.

9.B. Requests for Future Agenda Items

9.C. Upcoming Meetings and Events Calendar

- Next Regular Board Meeting - September 15, 2026
- ASBA Law Conference - September 9-11, 2026

10. ADJOURNMENT

Motion to adjourn by Eldon Larsen; second by Karsten Flake
Final Resolution: Motion passed
Yes: Eldon Larsen, Dayton Flake, Karsten Flake, Lexi Nelson
Time: 6:29 p.m.

APPROVED:

_____

Board Clerk or President

Minutes of Special Board Meeting of the Governing Board
Joseph City Unified School District
District Office Board Room, 8176 N. Westover, Joseph City, AZ 86032
Tuesday, August 25, 2026

Members present
Eldon Larsen, President; Dayton Flake, Clerk; Karsten Flake, Cat Hansen, Lexi Nelson

Administrators present
Shannon Harvilla, Superintendent; Eric Miller, JH/HS Principal; Pamela Dean, Elementary Principal

Others present
One community member

1. OPENING ITEMS

1.A. Call to Order
Motion by Eldon Larsen to call the meeting to order.
Time: 6:00 p.m.

1.B. Roll Call

1.C. Pledge of Allegiance

1.D. Invocation

1.E. Adoption of Agenda
Motion by Eldon Larsen to adopt the agenda as presented; second by Cat Hansen
Final Resolution: Motion passed.
Yes: Eldon Larsen, Dayton Flake, Karsten Flake, Cat Hansen, Lexi Nelson

2. EXECUTIVE SESSION (*)
None

3. PERSONNEL REQUESTS (*)
None

4. ACTION ITEMS

4.A. Request to Change JCUSD Academic Calendar 2026-27 - Spring Break Dates

Request to change the 2026-27 JCUSD Academic Calendar spring break dates from March 8-11, 2027 to March 15-18, 2027.

Note: this will also change the previously scheduled Parent Teacher conferences from March 18, 2027 to March 11, 2027.

Motion by Eldon Larsen to make the changes to the FY 2027, as requested; second by Lexi Nelson
Final Resolution: Motion passed.
Yes: Eldon Larsen, Dayton Flake, Karsten Flake, Cat Hansen, Lexi Nelson

5. DISCUSSION ITEMS

5.A. Schedule possible future dates for Policy Workshop.

Suggested that the Governing Board meet monthly on the third Fridays at 1:00 pm for Policy Workshops. Beginning with September 18, 2026 at 1:00 p.m.

6. INFORMATION ITEMS

7. ADJOURNMENT

Motion to adjourn by Eldon Larsen; second by Lexi Nelson
Final Resolution: Motion passed
Yes: Eldon Larsen, Dayton Flake, Karsten Flake, Cat Hansen, Lexi Nelson
Time: 6:05 p.m.

APPROVED:

_____
Board Clerk or President

4. **SUPERINTENDENT'S REPORT**

SUPERINTENDENT’S REPORT

Joseph City Unified School District No. 2
Regular Governing Board Meeting, Tuesday, September 15, 2026
Shannon Harvilla, Superintendent

Enrollment

We opened the year at 387 students. Five weeks in, we are at **389**, and the number that drives the budget has held.

Enrollment as reconciled by Julie Mills, September 9	August 11	September 9
Fundable, the count that generates state aid	360	361
Non-fundable, our ESA and tuition families	27	28
Total district enrollment	**387**	**389**
Budget projection this Board adopted (fundable)	**360.6**	**360.6**

We are at **361 fundable students against the 360.6 the budget was built on**, four-tenths of a student above our own projection. In August I told you I would rather give you one honest number in October than an optimistic one early, and that has not changed. The state takes its official count on October 1. Between now and then Julie Mills and Jason Gardner are working a numbered punch list on the handful of student records that are not yet generating average daily membership in the state system, because a student who is in our classroom but not in the state's count is worth nothing to the budget until the record is fixed. I pulled the state's data verification reports myself in August to find them. October 13 is when you get the audited count with the dollars attached.

ESA participation continues to grow. Since my last report the elementary is enrolling its first ESA family for individual classes, using the invoice process the junior high and high school built in July. I will bring you the updated ESA totals with the October count so you see the whole picture at once.

Our Students

Tonight you will recognize the first Wildcat Way Students of the Month, Ryslyn Fischer, Grace Birk, Charles Gardner and Kylie Hansen, nominated by staff for pride, courage, character and community. Their families were invited to sit near the front of the agenda so the kids do not wait through business items. Thank you to Lexi for suggesting it and to Mr. Miller for building the program.

Homecoming week ran September 8 through 12 with the theme All American Homecoming. There was no parade this year because the county paperwork did not clear in time, so the students held a community pool party festival on Thursday instead, with free swimming and games and cashless food sales. Powder Puff and Macho Volleyball were Wednesday, the junior high held its first dance of the year with the student council running it, volleyball hosted Round Valley on Friday with a September 11 remembrance before the matches, football hosted San Manuel that

night, and the dance was Saturday. The elementary ran its own dress days all week thanks to Mrs. A. Bushman and Mrs. L. Gayer.

Tori Beatty was named to the All-Tournament Team at the Payson volleyball tournament, chosen by the opposing coaches. Chess opened its season at Alchesay with Bryce and Synali representing us, and the team is at the Northland Prep tournament in Flagstaff this weekend. When the football home opener fell through, Tyler Murphy found a game in Bullhead City on short notice and Gina Spurlock drove the team.

The classroom posts keep coming and they are the best thing on our feed. Kindergarten made slime to learn the letter i. First graders spelled words with magic e and found every way to make ten with bowling pins. Third and fourth graders ask every day to play Smash to practice multiplication. Kay Rush's math students scaled recipes and made cookie dough with Mrs. Isaacson, which turned into the opening of a chemistry unit. Jess Bushman's Earth and Space students built towers that had to survive an earthquake on a vibration plate, and her biology students discovered that a food web is a tangle, not a pyramid. Photography students built pinhole cameras out of cardboard boxes. Junior high CAD students modeled their own Lego bricks and printed them to test the fit. Seventh graders debated the road to the Revolution. Elementary families can now see this work every week, and I want to thank every teacher who has taken the time to post it.

Our People

The 2026-27 Performance Pay Plan was ratified by the eligible staff with **26 of 28 votes in favor**, and it is on tonight's agenda with the Classroom Site Fund allocation of **$717,053**, which matches the budget you adopted to the dollar.

APS came to both campuses Monday morning. Through its Supply My Class program, an APS vice president who lives in Joseph City delivered $500 gift cards to four of our teachers, Kristen Beatty, Kay Rush, Daniel Hutchens and Taura Isaacson, for classroom supplies. That is $2,000 that goes straight to students, and it came to us because of the relationship this district has built with APS over the last year.

Invenergy's KidWind workshop on September 12 drew a large contingent from Joseph City, with Jess Bushman attending for the district. Jess was also accepted into the Algae Academy and is running it in two classes both semesters. Pamela Dean completed hearing and vision screener training in August, and Jori Mosier finished our first ever in-house hearing and vision screening before anyone asked twice. That decision ends a $3,000 annual vendor bill. Pamela and Ruth Hansen built the universal reading screening plan, and third, fourth and fifth grade screening is nearly complete. Pamela also named the district's literacy leadership team, which the state now requires, and the elementary ELA materials that were believed ordered last spring have now actually been ordered, with fourth and fifth grade added because the materials in use were out of date.

Staff Compass, our policy and ethics training, continues with completions coming in without anyone chasing people, and Julie Strong is tracking the last stragglers. Eric Miller's restorative discipline framework is in use district wide. We have joined the

state's principal evaluation pilot study, which lets us use the new observation system developmentally this year, and it answers a question I put to myself in August: our principals deserve a real evaluation, and this year they will get one. I completed the first session of the Supervisors of Principals Academy at the Department of Education in August, and the next is Thursday in Gilbert.

Tonight's consent agenda carries the appointment of Daniel Hutchens III as custodial manager and two resignations. I appreciate the service of everyone leaving us.

Safety and Operations

On September 4 I told you about a dismissal incident on September 2 at the elementary in which a fourth grader walked off campus after school and was found safe on the road within about twenty minutes by a teacher on his way home. I promised you the changes in writing. They have been in place since Tuesday, September 8:

- A written list at every release point. No child leaves until an adult crosses the name off and initials it.
- A required check at 3:45 confirming every student is accounted for, with the office calling parents immediately if anyone is not.
- Dismissal information travels with the last period class, not homeroom.
- Substitutes receive a written packet for every class they cover, and they sign for it.
- Third, fourth and fifth grade take attendance every rotation instead of at homeroom only.

Fourteen staff members wrote statements that evening, most after they had gone home, and eleven cleared the building in about six minutes on a badly short-staffed day. The gap was in our accounting, not in our people, and it is closed.

Separately, Mrs. Dean and Spencer Johnstun have worked out the morning bus arrival problem at the elementary. Students were coming off buses before duty staff were in the bus bay at 7:45. Drivers have adjusted their timing and staff are at their posts earlier, and we are reviewing camera footage this week to confirm it is holding.

Meal accounts changed this year. Every family started at zero thanks to 1GPA, and a student may now charge up to $100 before an alternate meal is offered, which is written into our Free and Reduced Price Meal Policy as approved by the Department of Education. Concessions and gate tickets went cashless through GoFan on September 4. Students and senior citizens are admitted free, and passes are at the high school front office.

We are working with Stantec on an asbestos assessment of both campuses, and on Monday I gave them the district's complete asbestos and AHERA records in one organized folder. In assembling those records I found that our most recent full AHERA re-inspection on file dates to **September 2017**. The law calls for one every three years. I would rather tell you that plainly and fix it than have you learn it from a consultant, and the assessment is the first step.

Facilities and the State Facilities Division

On tonight's agenda are three resolutions I asked to have under action rather than consent so you see them: the FY27 Capital Plan, the Building Inventory, and the Preventive Maintenance Plan that Brad Neal and I built from scratch, system by system. As I told you on August 28, this district filed only one of its four required annual reports to the Division in 2024 and 2025, and three of the four are prerequisites for the Building Renewal Grant money that is paying for our boilers and chiller. Building inventory and renovation expenditures are filed. Tonight's resolutions finish the set, and I told our liaison in writing ahead of the deadline why the last one had to wait for you.

The elementary boiler replacement grant is active and the purchase order is with Pueblo Mechanical. Annual boiler maintenance at both campuses is locked at $21,000 with the scope in writing. The elementary chiller grant is active. The Division approved our activity report on the junior high and high school HVAC project on September 11, and at 1:00 today I met with Ken Poocha of the Division, Karuna Brewer, our grant consultant, and Trane on the pre-design for that project. This is a multi-year, multi-million dollar replacement of the heating and cooling at the junior high and high school, and the question in front of us is how to sequence it against the boiler work already funded so we do not pay for equipment twice. We also submitted an emergency grant request for the elementary walk-in refrigerator, which is being finalized with the Division, and the documentation the Division asked for on the high school public announcement and telecommunications system is being assembled this week.

Money

A few items, all of them cleaner than they were a month ago.

The 1GPA gift of **$12,088.96** that paid every family's cafeteria balance is on tonight's agenda for formal acceptance. It cost the district nothing but a thank you note.

The county discrepancy that briefly made our budget balance look negative is resolved. It was never a cash problem. Our cash position was over $400,000 the entire time; a journal entry posted on our books had not been processed on the Treasurer's books. Victoria Farrar confirmed the county processed it and the warrants are released.

The state closed our prior year fully paid at **$1,525,097.72** with nothing pending, confirmed in writing to Caleb. The roughly $224,000 second payment our old records were counting on never existed, and it is better to know that now than to build on it. The state aid advance request and the county line of credit request, both under the resolution you passed, are filed.

Caleb and Selena have been delivering every document the Auditor General's office has asked for, and their card sample is due Thursday. My rule with them has not changed: hand them everything, explain everything, hide nothing.

Two items for budget season. Substitute pay last year was just under $170,000 across thirty-six people, and this year's budget carries about $70,000; Caleb and

Victoria have it. And our ESEA Consolidated application, which carries Title I-A and Title II-A, needed revisions from the state reviewer; those are in progress ahead of the September 29 approval date.

August vouchers on tonight's consent agenda total $217,973.05, and they tie to the ledger to the cent.

Policy and Governance

We now hold a complete, verified copy of the policy manual, all 612 documents checked one at a time against ASBA PolicyBridge on August 13, and we have organized the ASBA advisories back to 2020 alongside it. Tonight you adopt the eighteen documents from ASBA Advisories 1047 through 1064, which reflect this year's legislative session, and that adoption also fills the seven admissions and residency regulations the manual was missing. Two August advisories, on board member conflict of interest and the new purchasing ethics regulation, are being introduced this month for adoption October 13. Two more from August, on employee conflict of interest and the credit card policy family, will get first read October 13 and adoption November 10.

Friday at 1:00 is the first monthly policy workshop, a noticed public meeting, discussion only. You will have the packet Thursday. The plan I will ask you to agree to works all 324 board policies by section between now and April, with each section adopted two meetings after it is reviewed, so that the whole manual is current by June 8. I have designated myself Title IX Coordinator and will update the regulation and the public notices in October. And I read our restraint and seclusion policy against the current statute this week; the policy is current, and I am issuing the documentation procedures it requires, with a training plan, in October.

Partnerships and Career Pathways

Career pathways remain the through line of this year. On August 27 I represented the district at the Governor's Office Northeast Arizona Energy Infrastructure Roundtable in Holbrook, and on September 1 Kelly Zagrzebski of Invenergy and Jack Callahan of Navajo County met with me here to build the energy career pathways matrix; Dan Bushman and Mari Hansen are writing our program language for it this week. On August 25 I met with Northland Pioneer College President Lawson and Richard Chanick on dual enrollment and pathways, which is what drove the calendar change you approved on August 25 to align our spring break with NPC and NAVIT. Our data sharing agreement with Grand Canyon University for seniors is final, with Dan Bushman as our contact. I attended the ASBA Law Conference and Delegate Assembly in Scottsdale last week, where Lexi served as our delegate.

Two new community pieces. This afternoon I met with Alicia Shugart, Navajo County Public Health's teen health program manager, about the county's free life skills programming; anything in that program that touches sensitive subjects would come to you first under the process state law requires, and nothing was committed. And Parents Supporting Wildcats now has an online request portal, built by Jason Gardner, so the group can take and track requests from staff for the first time.

Looking Ahead

- Friday, September 18: policy workshop at 1:00, and Enrichment Day at the elementary.
- September 22: Grand Canyon University Superintendents Collaborative Network, session two.
- September 23: our dry run for the October 1 count.
- September 24 to 26: Arizona Rural Schools Association conference in Flagstaff. I will commute.
- September 26: Family History Festival.
- October 1: the state's official enrollment count.
- October 13: regular meeting, with the audited count and the funding consequence in dollars, as promised.
- December 8: Beyond Textbooks visits the board.

Come to the games. This town shows up for its kids, and that is an advantage no other option can offer.

Respectfully submitted,
Shannon Harvilla, Superintendent

4.A. **Wildcat Way Students of the Month**

Students of the Month for August 2026
Ryslyn Fischer
Grace Birk
Charles Gardner
Kylie Hansen

5. **REQUESTS TO SPEAK TO THE GOVERNING BOARD**

The procedure for addressing the Board in a public meeting may be viewed here: https://josephcityaz.sites.thrillshare.com/page/public-comments

6. **CONSENT AGENDA**

Vote on Consent Agenda. All items listed will be considered as a group and will be approved with one motion unless a Board Member requests an item be removed from the consent agenda and considered as a separate item.

6.A. **Approve Expense Vouchers**

Action to ratify district vouchers for the period August 1, 2026 through August 31, 2026.

General and Special Funds: #1003, #1004, #1005, #1006 — $217,973.05

Auxiliary Operations Funds: Pending August payroll and External Accounts reconciliation.

Student Activities Fund: Pending August payroll and External Accounts reconciliation.

6.B. **Student Activities Fund Report**

Revenues, expenditures and charges in the Student Activities Fund Report; period of August 1, 2026 through August 31, 2026.

6.C. **Student Fundraisers**

Organization	Description	Action
Class of 2027	Snowcone Sales	Ratify
Class of 2030	Cotton Candy Sales	Ratify
HS Boys Basketball	School Fundr Online donations	Approve
Student Council	Homecoming Dance	Ratify

6.D. **Gifts & Donations**

Donor	Item	School/Program	Purpose	Amount
1 GPA	check	District wide Student Accounts	Bringing All outstanding Lunch Accounts to Date	$12, 088.96
Arizona Diamondbacks Foundation	check	Youth Sports	To support Sports in the schools	$1000

Arizona Diamondbacks Foundation
401 E. Jefferson Street
Phoenix, AZ 85004

July 10, 2026

Joseph City Unified School District
P.O. Box 8
Joseph City, AZ 86032

On behalf of the Arizona Diamondbacks Foundation, it is my pleasure to congratulate you and your organization on being selected as a 2026 recipient of the D-backs Play Ball Fund!

Enclosed you will find your check in the amount of $1,000, which reflects our commitment to supporting youth sports across Arizona. This funding is intended to directly benefit your league and help ensure more kids can play, grow, and thrive on and off the field.

We're grateful for the work you do to make the game more accessible, inclusive, and impactful in your community. Your dedication to youth sports inspires us, and we're proud to be a part of your season.

Thank you again for all you do, and best of luck this season!

With gratitude,

Debbie Castaldo
Sr. Vice President, Corporate and Community Impact
Arizona Diamondbacks

6.E. **Approve FY 2026-27 Fee Schedules**

FY 2026-27 Fee Schedules: Community Use of Facilities Fees, JH/HS activity Fees, Elementary / Preschool Tuition and Fees.

COMMUNITY USE OF
SCHOOL FACILITIES

SCHOOL FACILITIES USER FEES

Class I ***Fees*** No charge for District Mission related use.

School-sponsored activities	Teacher Organizations
School Clubs	P.T.A. / Organizations
Boy Scouts	Booster clubs
Girl Scouts	Arizona Youth Soccer Organization
Little League Program	

Class II ***Fees*** See below

Community college	Civic organizations
Community-sponsored concerts	Educational organizations
Churches	Government organizations
Recitals	Service organizations
Cultural organizations	Extended day resource programs
Other nonprofit groups	

Class III ***Individual User Fees*** See below

Class IV ***Fees*** See below

Commercial or profit-making organizations

Facility	**Class II/III**	**Class IV**
Classroom-Standard	$ 15.00 per hour	$ 20.00 per hour
Board room	$ 20.00 per hour	$ 25.00 per hour
Computer lab	$ 30.00 per hour	$ 60.00 per hour
Specialized classroom	$ 25.00 per hour	$ 50.00 per hour
Auditorium*	$ 50.00 per hour *2 hour minimum*	$ 100.00 per hour *2 hour minimum*
Gymnasium High school and elementary	$ 45.00 per hour	$ 70.00 per hour
Gymnasium - Old	$ 20.00 per hour	$ 40.00per hour
High school/elementary Cafeteria and kitchen*	$ 30.00 per hour *2 hour minimum*	$ 70.00 per hour *2 hour minimum*
High school/elementary Cafeteria only	$ 20.00 per hour *2 hour minimum*	$ 60.00 per hour *2 hour minimum*

Football stadium w/o lights	$ 40.00 per hour *2 hour minimum*	$ 70.00 per hour *2 hour minimum*
Football stadium with lights	$ 70.00 per hour *2 hour minimum*	$ 100.00 per hour *2 hour minimum*
Outdoor playfield w/o lights	$ 40.00 per hour *2 hour minimum*	$ 70.00 per hour *2 hour minimum*
Pool*	$ 60.00 per hour *2 hour minimum*	$ 100.00 per hour *2 hour minimum*
Activity/Multipurpose room	$ 45.00 per hour	$ 60.00 per hour

* Requires personnel on-site - extra charges apply.

Pool Rates:

Lessons- $25.00 a session per student

Lap Swim and Special Classes- $25.00 per person per month

Open Swim Sessions- $2.00 per person per entry

Family Pass- $100 per year for one household pass into all open swim sessions held on afternoons and nights.

Racquetball:

$15 per person a month and must be paid thru December 31 each year. This will be prorated down each month according to the time of the year that the payment is made.

Fitness Club:

$140 per person per year and goes through December 31. This will be prorated down to $70.00 starting July 1. Fitness club membership provides access to the racquetball courts, lap swim/special classes, morning basketball, and the weight room, during designated hours. Facilities will only be opened at designated times and when they do not conflict with school activities. Facility times and dates are subject to change no refunds are allowed.

Goods and Services Contributed

A person, group or organization may contribute goods or render services as full or partial payment of the user fee. The value of the goods will be determined by the District based upon established market price, trade in value, posted prices or where these methods prove impractical, appraisal or barter may be employed so long as the procedure is advantageous to the District. The value of services rendered shall be based upon the hourly wages of a beginning employee of this or another Arizona School District performing similar functions as determined by the District. Should disagreement between the contributor and the District occur as to the value of the goods or services offered, the District reserves the right to refuse to accept the offer.

Elementary School Fees

Updated 9/15/2026

PRESCHOOL

- No charge for students who have been identified with special needs.
- Preschool – 8 monthly payments of $90 = $720 per year; incentives for early payoff or parent volunteers, not to exceed 5%

FIELD TRIPS

- Ranges from $0.00 to $5.00

AFTER SCHOOL ACTIVITIES

- INTERMURAL BASKETBALL
- INTERMURAL SOCCER

NOTICE

Economically disadvantaged families may apply for a waiver or reduction for Field Trips and After School Activities. Inquire at the office for an application if you would like to apply. Approval is based on need and free/reduced lunch status.

Jr/Sr High School Fees

Joseph City Schools
Tradition of Excellence

Revised 7/11/2023

HIGH SCHOOL

ART	$20.00 per semester Students will need to pay for extra for any materials used beyond what is required for class.
WOODS and WELDING	Students will pay for metal and other materials used for projects.

ATHLETICS

HIGH SCHOOL ATHLETIC REGISTRATION	$45.00 per sport for the first two sports. Any additional sport is free.
JUNIOR HIGH ATHLETIC REGISTRATION	$25.00 per sport for the first two sports. Any additional sport is free.
ATHLETIC EVENT ENTRY FEES	JCHS Students- Free $5- General Admission $3- Students from other schools $3- Seniors

ACTIVITIES

DRAMA/HIGH SCHOOL PLAY REGISTRATION	$20.00
Family Maximum Charge for Athletics & Activities	$200.00

Economically disadvantaged families may apply for a waiver or reduction for athletic/activity registration fees. Inquire at the office for an application if you would like to apply. Approval is based on free/reduced lunch status.

ACTIVITY CARDS

Activity cards cover entry to all home athletic events run by Joseph City Jr/Sr High School. AIA Playoff games are not included.

ADULTS	$50.00

7. **POSSIBLE EXECUTIVE SESSION (*)**

For any agenda item indicated with an asterisk (*), the Board may vote to convene in Executive Session pursuant to A.R.S. 38-431.03 (A) (1) for personnel matters when notified; (2) discussion or consideration of records exempt by law from public inspection; (3) for consultation with attorney; (4) for consultation with attorney when in pending or contemplated litigation. Discussion or consideration of personnel matters may include employment, assignment, appointment, promotion, demotion, dismissal, salaries, disciplining or resignation of a public officer, appointee or employee.

8. **ACTION ITEMS**

8.A. **Personnel Requests (*)**

Name	Assignment	Action
Bowler, Laurie	JH/HS Tutor	Assignment
Brown, Kevin	Volunteer, Athletic	Acceptance
Bushman, Adriane	Preschool Aide	Appointment
Bushman, Adriane	Elementary Yearbook Coordinator	Assignment
Bushman, Jess	Science Fair Coordinator	Assignment
DeShazor, Steven	Custodial Coordinator	Resignation
Edwards, Sydnee	JH Softball Volunteer	Acceptance
Fish, Kari	JH Softball Volunteer	Acceptance
Hansen, Ruth	Title I Coordinator - ESI contracted Employee	Resignation Effective 10/1/26
Hutchens, Daniel III	Custodial Coordinator	Appointment
Johnstun, Aaron	JH/HS Tutor	Assignment
Metzger, Kelly	Red Ribbon Week Coordinator	Assignment
Miller, Ava	Substitute Teacher*	Appointment
Moss, Benson	Auditorium Tech	Appointment
Smith, Jim	Event worker	Renewal

September 10, 2026

Dear Superintendent, Shannon Harvilla,

I have loved working for the Joseph City School District. It has been a complete joy these last eleven years. I thank you and the district for this opportunity. Our district is amazing to work for. It is with a heavy heart that I resign my position on October 1, 2026. I have a business to run and the responsibilities of the business weigh heavily on my shoulders.

Please know that I appreciate the school district and all the wonderful years I have worked here. I hope to volunteer and still be a part of the growth of the school.

Thank you for all you do to make this school a better place.

Sincerely,

Ruth Hansen

Resignation Letter

09/03/2026

JCUSD

Steven De Shazor – Lead Custodian

To whom it may concern,

I would like to inform you that I am submitting my resignation from my position as lead custodian effective 09/10/2026. Thank you for all the support and opportunities you have provided for me. I am grateful for the experience and encouragement I have been given for me to further pursue my professional and personal goals.

I am still available to be a sub, as needed, bus driver. My schedule will vary and I will mainly be available to assist in the evenings and weekends, when the need arises. I will do all I can to assist in training another team member to take over my duties as lead custodian and help this transition period, as I prepare to leave.

I wish the JCUSD continued success in the future and thank you again for all the opportunities I have been given.

Sincerely,

Steven De Shazor

8.A.(i) **Personnel Requests (*)**

Name	Assignment	Action
Spurlock, Sharon	Substitute Teacher	Appointment

8.B. **Resolution: 2027-1 reventative Maintenance Guideline and Plan**

JOSEPH CITY UNIFIED SCHOOL DISTRICT NO. 2 NAVAJO COUNTY, ARIZONA

RESOLUTION NO. 2027-1

A RESOLUTION OF THE GOVERNING BOARD ADOPTING THE DISTRICT'S 2026 PREVENTIVE MAINTENANCE GUIDELINE AND PLAN

WHEREAS, A.R.S. § 41-5702(L) requires each school district to develop routine preventive maintenance guidelines for its facilities, including plumbing systems, electrical systems, heating, ventilation and air conditioning systems, special equipment and other systems, and, for roofing systems, to recommend visual inspections performed by district staff for signs of structural stress and weakness; and

WHEREAS, the guidelines must be submitted to the School Facilities Division of the Arizona Department of Administration for review and approval; and

WHEREAS, the Superintendent and the Facilities Director have developed the 2026 Preventive Maintenance Guideline and Plan for Joseph City Unified School District No. 2, covering both district campuses and addressing task prioritization, a detailed maintenance schedule at daily through annual intervals, optimization of employee work hours, use of technology, staff education and training, continuity of operations and recordkeeping, continuous improvement, and program successes and goals; and

WHEREAS, the Plan incorporates the district's vendor service agreements on major building systems, the district's semi-annual roof inspections by district staff, the Facilities Records Retention Schedule, and the district's Building Renewal Grant Three to Five Year Plan; and

WHEREAS, the Plan was submitted to the School Facilities Division through the Division's designated process on August 31, 2026 as submission PM-00356, in advance of the September 1, 2026 deadline;

NOW, THEREFORE, BE IT RESOLVED by the Governing Board of Joseph City Unified School District No. 2 that:

1. The 2026 Preventive Maintenance Guideline and Plan is adopted as the routine preventive maintenance guideline of the district under A.R.S. § 41-5702(L).
2. The Board ratifies the submission of the Plan to the School Facilities Division.
3. The Board President, the Superintendent, and the Facilities Director are authorized to execute the Plan's signature page, and the Superintendent is directed to file this Resolution and the signed Plan with the School Facilities Division.
4. The Plan shall be reviewed annually by the Facilities Director and the Superintendent and returned to the Board with any material revisions.

PASSED AND ADOPTED by the Governing Board of Joseph City Unified School District No. 2 this 15th day of September, 2026.

Board President

Board Clerk / Member

ATTEST:

Superintendent

Vote: Ayes ____ Nays ____ Abstain ____ Absent ____

8.C. **Resolution: FY 2027-2 Capital Plan**

JOSEPH CITY UNIFIED SCHOOL DISTRICT NO. 2 NAVAJO COUNTY, ARIZONA

RESOLUTION NO. 2027-2

A RESOLUTION OF THE GOVERNING BOARD APPROVING THE DISTRICT'S FISCAL YEAR 2027 CAPITAL PLAN

WHEREAS, A.R.S. § 41-5741(C) requires each school district to submit a capital plan to the School Facilities Oversight Board by September 1 of each year, and to request monies from the new school facilities fund if the plan indicates a need for a new school or an addition to an existing school within the next four years, or a need for land within the next ten years; and

WHEREAS, the district prepared its Fiscal Year 2027 Capital Plan (CP-00108), including average daily membership projections for fiscal years 2027 through 2037 prepared by the cohort survival method and verified against state enrollment records, a master plan narrative, and the district's land inventory; and

WHEREAS, district enrollment has declined from 455 students in fiscal year 2023 to 387 students in fiscal year 2027, a decline of approximately fifteen percent, and average daily membership is projected to decline further from 355 in fiscal year 2027 to 209 in fiscal year 2037, and the Plan accordingly identifies no need for a new school or an addition to an existing school within the statutory four year window and no need for land within the statutory ten year window; and

WHEREAS, the Plan states that the district's capital priorities are the renewal and right sizing of existing facilities, including the elementary boiler and chiller replacements now underway through Building Renewal Grants; and

WHEREAS, the Plan was submitted to the School Facilities Division portal on August 31, 2026, in advance of the September 1, 2026 deadline;

NOW, THEREFORE, BE IT RESOLVED by the Governing Board of Joseph City Unified School District No. 2 that:

1. The Fiscal Year 2027 Capital Plan of the district is approved as submitted.
2. The Board ratifies the Superintendent's timely submission of the Plan and the accompanying attestations.
3. The Superintendent is directed to file this Resolution with the School Facilities Division in the Plan's Governing Board Resolution record.
4. The Superintendent shall report to the Board any response from the Division, including any action concerning the district's building capacity records or Minimum Adequacy Guidelines assessment.

PASSED AND ADOPTED by the Governing Board of Joseph City Unified School District No. 2 this 15th day of September, 2026.

Board President

Board Clerk / Member

ATTEST:

Superintendent

Vote: Ayes ____ Nays ____ Abstain ____ Absent ____

8.D. **Resolution : FY2027-3 Building Inventory**

JOSEPH CITY UNIFIED SCHOOL DISTRICT NO. 2 NAVAJO COUNTY, ARIZONA

RESOLUTION NO. 2027-3

A RESOLUTION OF THE GOVERNING BOARD CERTIFYING THE DISTRICT'S ANNUAL BUILDING INVENTORY

WHEREAS, the School Facilities Division of the Arizona Department of Administration maintains records of school district building inventories, including gross and net square footage, as part of the Division's administration of the building renewal grant fund and the minimum school facility adequacy guidelines under A.R.S. Title 41, Chapter 57; and

WHEREAS, the Division's annual reporting calendar required the district's building inventory report by September 1, 2026, and identifies the report as a prerequisite for Building Renewal Grant participation; and

WHEREAS, the district reviewed its building inventory for both campuses, including the Jr/Sr High campus of approximately 125,646 gross square feet across ten buildings constructed between 1973 and 2010, and the elementary campus, together with the district's supporting facility records and digitized as-built drawings; and

WHEREAS, in the course of that review the district also created its first building system asset record with the Division and identified no reductions in district square footage requiring separate action before the School Facilities Oversight Board; and

WHEREAS, the building inventory report was submitted to the Division on August 28, 2026, in advance of the September 1, 2026 deadline;

NOW, THEREFORE, BE IT RESOLVED by the Governing Board of Joseph City Unified School District No. 2 that:

1. The district's 2026 building inventory report is approved, and the Board certifies that to the best of its knowledge the inventory accurately reflects the buildings and square footage of the district.
2. The Board ratifies the timely submission of the report to the School Facilities Division.
3. The Superintendent is directed to file this Resolution with the Division and to continue building out the district's building system asset records.

PASSED AND ADOPTED by the Governing Board of Joseph City Unified School District No. 2 this 15th day of September, 2026.

Board President

Board Clerk / Member

ATTEST:

Superintendent

Vote: Ayes ___ Nays ___ Abstain ___ Absent ___

8.E. **PUBLIC HEARING and Approval of 2026-27 Performance Pay Plans for Teachers and Certified Specialists and Classroom Site Fund Allocation.**

8.F. **Adoption of High School Environmental Science textbook and curriculum materials.**
Textbooks, supplementary materials and online resources proposed for adoption are High School Environmental Science PDF version of Environmental Science Copyright© by Holt, Rinehart and Winston
Text that students would use for their textbook assignments is the PDF version of Environmental Science Copyright© by Holt, Rinehart and Winston
https://anyflip.com/qjhij/xqst/basic

https://drive.google.com/open?id=1HVZpKA9EgPs5H03uhNIJ0qc0Bm-HnTK5

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Biological Sciences Open Textbooks | Biological Sciences

Spring 2018

Introduction to Environmental Science: 2nd Edition

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Open Textbook
Georgia College and State University

UNIVERSITY SYSTEM OF GEORGIA

Caralyn Zehnder, Kalina Manoylov, Samuel Mutiti,
Christine Mutiti, Allison VandeVoort, Donna Bennett

Introduction to Environmental Science

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Chapter 1: Introduction to Environmental Sciences

Learning Objectives

At the end of this section, students will be able to:

1. Describe, at an introductory level, the basic chemical and biological foundations of life on Earth
2. Define environment, ecosystems, and environmental sciences
3. Give examples of the interdisciplinary nature of environmental science
4. Define sustainability and sustainable development
5. Explain the complex relationship between natural and human systems, pertaining to environmental impact, the precautionary principle, and environmental justifications
6. Understand scientific approach and begin to apply the scientific method

The Chemical and Biological Foundations of Life

Elements in various combinations comprise all matter on Earth, including living things. Some of the most abundant elements in living organisms include carbon, hydrogen, nitrogen, oxygen, sulfur, and phosphorus. These form the nucleic acids, proteins, carbohydrates, and lipids that are the fundamental components of living matter. Biologists must understand these important building blocks and the unique structures of the atoms that make up molecules, allowing for the formation of cells, tissues, organ systems, and entire organisms.

At its most fundamental level, life is made up of matter. **Matter** is any substance that occupies space and has mass. **Elements** are unique forms of matter with specific chemical and physical properties that cannot be broken down into smaller substances by ordinary chemical reactions. There are 118 elements, but only 92 occur naturally. The remaining elements are synthesized in laboratories and are unstable. The five elements common to all living organisms are oxygen (O), carbon (C), hydrogen (H), and nitrogen (N) and phosphorous (P). In the non-living world, elements are found in different proportions, and some elements common to living organisms are relatively rare on the earth as a whole (**Table 1.1**). For example, the atmosphere is rich in nitrogen and oxygen but contains little carbon and hydrogen, while the earth's crust, although it contains oxygen and a small amount of hydrogen, has little nitrogen and carbon. In spite of their differences in abundance, all elements and the chemical reactions between them obey the same chemical and physical laws regardless of whether they are a part of the living or non-living world.

Table 1.1. Approximate percentage of elements in living organisms (from bacteria to humans) compared to the non-living world. Trace represents less than 1%.

	Biosphere	Atmosphere	Lithosphere
Oxygen (O)	65%	21%	46%
Carbon (C)	18%	trace	trace
Hydrogen (H)	10%	trace	trace
Nitrogen (N)	3%	78%	trace
Phosphorus (P)	trace	trace	>30%

The Structure of the Atom

An **atom** is the smallest unit of matter that retains all of the chemical properties of an element. For example, one gold atom has all of the properties of gold in that it is a solid metal at room temperature. A gold coin is simply a very large number of gold atoms molded into the shape of a coin and containing small amounts of other elements known as impurities. Gold atoms cannot be broken down into anything smaller while still retaining the properties of gold. An atom is composed of two regions: the **nucleus**, which is in the center of the atom and contains protons and neutrons, and the outermost region of the atom which holds its electrons in orbit around the nucleus, as illustrated in **Figure 1.1**. Atoms contain protons, electrons, and neutrons, among other subatomic particles. The only exception is hydrogen (H), which is made of one proton and one electron with no neutrons.

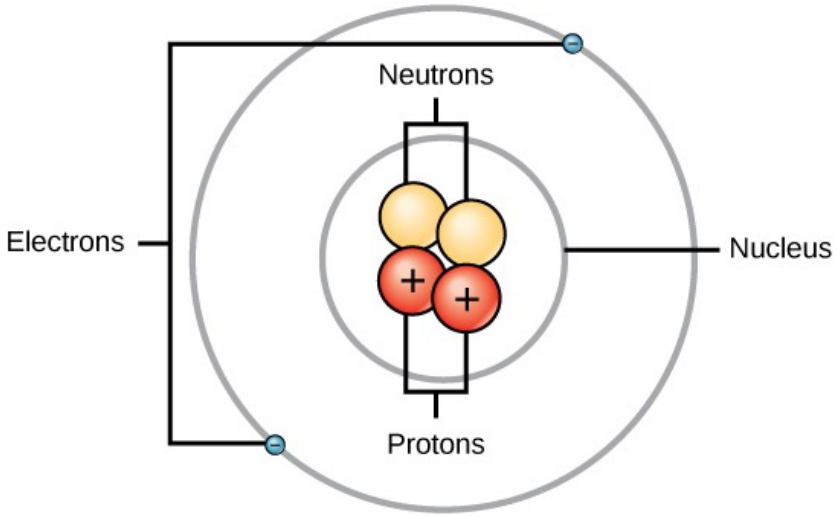


Figure 1.1. Elements, such as helium, depicted here, are made up of atoms. Atoms are made up of protons and neutrons located within the nucleus, with electrons in orbitals surrounding the nucleus.

Protons and neutrons have approximately the same mass, about 1.67×10^{-24} grams. Scientists arbitrarily define this amount of mass as one atomic mass unit (amu) (**Table 1.2**). Although similar in mass, protons and neutrons differ in their electric charge. A **proton** is positively

charged whereas a **neutron** is uncharged. Therefore, the number of neutrons in an atom contributes significantly to its mass, but not to its charge.

Table 1.2. Protons, neutrons, and electrons

	Charge	Mass (amu)	Location in atom
Proton	+1	1	Nucleus
Neutron	0	1	Nucleus
Electron	-1	0	Orbitals

Electrons are much smaller in mass than protons, weighing only 9.11×10^{-28} grams, or about 1/1800 of an atomic mass unit. Hence, they do not contribute much to an element's overall atomic mass. Although not significant contributors to mass, electrons do contribute greatly to the atom's charge, as each electron has a negative charge equal to the positive charge of a proton. In uncharged, neutral atoms, the number of electrons orbiting the nucleus is equal to the number of protons inside the nucleus. In these atoms, the positive and negative charges cancel each other out, leading to an atom with no net charge. Accounting for the sizes of protons, neutrons, and electrons, most of the volume of an atom—greater than 99 percent—is, in fact, empty space. With all this empty space, one might ask why so-called solid objects do not just pass through one another. The reason they do not is that the electrons that surround all atoms are negatively charged and negative charges repel each other. When an atom gains or loses an electron, an **ion** is formed. Ions are charged forms of atoms. A positively charged ion, such as sodium (Na^+), has lost one or more electrons. A negatively charged ion, such as chloride (Cl^-), has gained one or more electrons.

Molecules

Molecules are formed when two or more atoms join together through chemical bonds to form a unit of matter. Throughout your study of environmental science, you will encounter many molecules including carbon dioxide gas. Its chemical formula is CO_2, indicating that this molecule is made up of one carbon atom and two oxygen atoms. Some molecules are charged due to the ions they contain. This is the case for the nitrate (NO_3^-), a common source of nitrogen to plants. It contains one nitrogen atom and three oxygen atoms, and has an overall charge of negative one.

Isotopes

Isotopes are different forms of an element that have the same number of protons but a different number of neutrons. Some elements—such as carbon, potassium, and uranium—have naturally occurring isotopes. Carbon-12 contains six protons, six neutrons, and six electrons; therefore, it has a mass number of 12 (six protons and six neutrons). Carbon-14 contains six protons, eight neutrons, and six electrons; its atomic mass is 14 (six protons and eight electrons). These two alternate forms of carbon are isotopes. Some isotopes may emit neutrons, protons, and electrons,

and attain a more stable atomic configuration (lower level of potential energy); these are radioactive isotopes, or **radioisotopes**. Radioactive decay describes the energy loss that occurs when an unstable atom's nucleus releases radiation, for example, carbon-14 losing neutrons to eventually become carbon-12.

Carbon

The basic functional unit of life is a cell and all organisms are made up of one or more cells. Cells are made of many complex molecules called macromolecules, such as proteins, nucleic acids (RNA and DNA), carbohydrates, and lipids. The macromolecules are a subset of **organic molecules** that are especially important for life. The fundamental component for all of these macromolecules is carbon. The carbon atom has unique properties that allow it to form covalent bonds with as many as four different atoms, making this versatile element ideal to serve as the basic structural component, or "backbone," of the macromolecules.

Hydrocarbons

Hydrocarbons are organic molecules consisting entirely of carbon and hydrogen, such as methane (CH_4. We often use hydrocarbons in our daily lives as fuels—like the propane in a gas grill or the butane in a lighter. The many covalent bonds between the atoms in hydrocarbons store a great amount of energy, which is released when these molecules are burned (oxidized). Methane, an excellent fuel, is the simplest hydrocarbon molecule, with a central carbon atom bonded to four different hydrogen atoms, as illustrated in **Figure 1.2**.

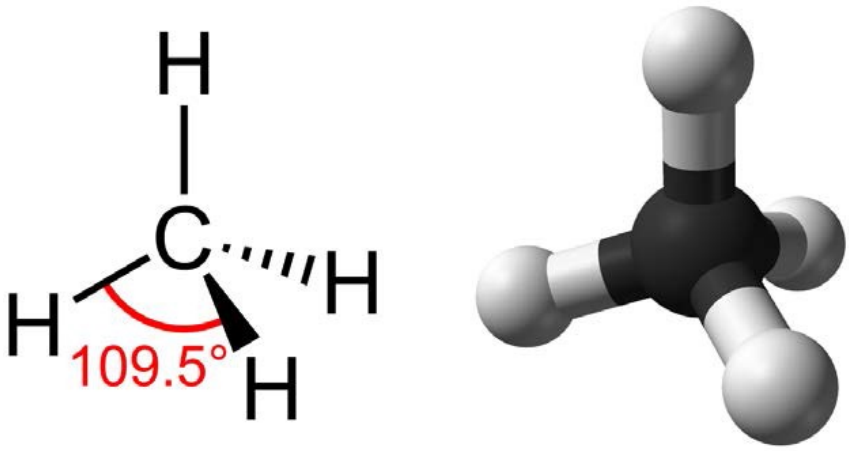


Figure 1.2. Methane (CH_4) has a tetrahedral geometry, with each of the four hydrogen atoms spaced 109.5° apart.

As the backbone of the large molecules of living things, hydrocarbons may exist as linear carbon chains, carbon rings, or combinations of both. This three-dimensional shape or conformation of the large molecules of life (macromolecules) is critical to how they function.

Biological molecules

Life on Earth is primarily made up of four major classes of biological molecules, or biomolecules. These include carbohydrates, lipids, proteins, and nucleic acids.

Most people are familiar with **carbohydrates**, one type of macromolecule, especially when it comes to what we eat. Carbohydrates are, in fact, an essential part of our diet; grains, fruits, and vegetables are all natural sources of carbohydrates. Carbohydrates provide energy to the body, particularly through **glucose**, a simple sugar that is a component of **starch** and an ingredient in many staple foods. Carbohydrates also have other important functions in humans, animals, and plants. Carbohydrates can be represented by the stoichiometric formula $(CH_2O)n$, where n is the number of carbons in the molecule. In other words, the ratio of carbon to hydrogen to oxygen is 1:2:1 in carbohydrate molecules. This formula also explains the origin of the term "carbohydrate": the components are carbon ("carbo") and the components of water (hence, "hydrate"). The chemical formula for glucose is $C_6H_{12}O_6$. In humans, glucose is an important source of energy.

During **cellular respiration**, energy is released from glucose, and that energy is used to help make **adenosine triphosphate** (ATP). Plants synthesize glucose using carbon dioxide and water, and glucose in turn is used for energy requirements for the plant. Excess glucose is often stored as starch that is catabolized (the breakdown of larger molecules by cells) by humans and other animals that feed on plants. Plants are able to synthesize glucose, and the excess glucose, beyond the plant's immediate energy needs, is stored as starch in different plant parts, including roots and seeds. The starch in the seeds provides food for the embryo as it germinates and can also act as a source of food for humans and animals.

Lipids include a diverse group of compounds such as fats, oils, waxes, phospholipids, and steroids that are largely nonpolar in nature. Nonpolar molecules are hydrophobic ("water fearing"), or insoluble in water. These lipids have important roles in energy storage, as well as in the building of cell membranes throughout the body.

Proteins are one of the most abundant organic molecules in living systems and have the most diverse range of functions of all macromolecules. Proteins may be structural, regulatory, contractile, or protective; they may serve in transport, storage, or membranes; or they may be toxins or enzymes. Each cell in a living system may contain thousands of proteins, each with a unique function. Their structures, like their functions, vary greatly.

Enzymes, which are produced by living cells, speed up biochemical reactions (like digestion) and are usually complex proteins. Each enzyme has a specific shape or formation based on its use. The enzyme may help in breakdown, rearrangement, or synthesis reactions.

Proteins have different shapes and molecular weights. Protein shape is critical to its function, and many different types of chemical bonds maintain this shape. Changes in temperature, pH, and exposure to chemicals may cause a protein to **denature**. This is a permanent change in the shape of the protein, leading to loss of function. All proteins are made up of different arrangements of the same 20 types of **amino acids**. These amino acids are the units that make up proteins. Ten of these are considered essential amino acids in humans because the human body cannot produce them and they are obtained from the diet. The sequence and the number of amino acids ultimately determine the protein's shape, size, and function.

Nucleic acids are the most important macromolecules for the continuity of life. They carry the genetic blueprint of a cell and carry instructions for the functioning of the cell. The two main types of nucleic acids are **deoxyribonucleic acid (DNA)** and **ribonucleic acid (RNA)**. DNA is the genetic material found in all living organisms, ranging from single-celled bacteria to multicellular mammals. DNA controls all of the cellular activities by turning the genes "on" or "off." The other type of nucleic acid, RNA, is mostly involved in protein synthesis.
DNA has a double-helix structure (**Figure 1.3**).

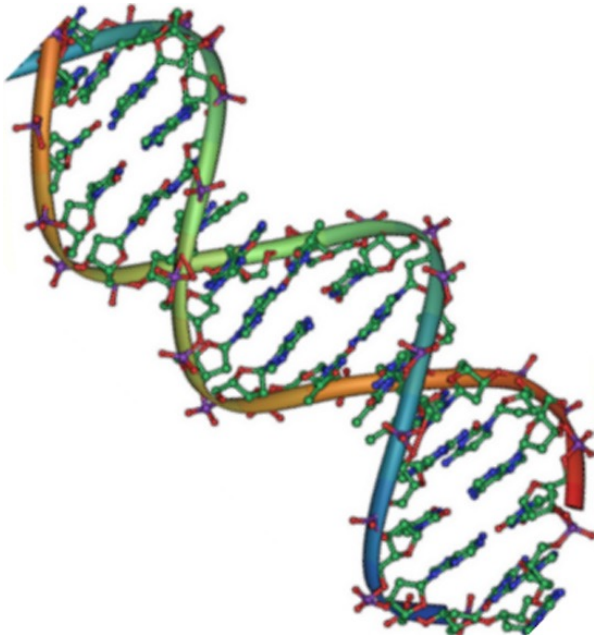


Figure 1.3. Native DNA is an antiparallel double helix. The phosphate backbone (indicated by the curvy lines) is on the outside, and the bases are on the inside. Each base from one strand interacts via hydrogen bonding with a base from the opposing strand. (credit: Jerome Walker/Dennis Myts)

Biological organization

All living things are made of cells; the **cell** itself is the smallest fundamental unit of structure and function in living organisms. In most organisms, these cells contain **organelles**, which provide specific functions for the cell. Living organisms have the following properties: all are highly organized, all require energy for maintenance and growth, and all grow over time and respond to their environment. All organisms adapt to the environment and all ultimately reproduce contributing genes to the next generation. Some organisms consist of a single cell and others are multicellular. **Organisms** are individual living entities. For example, each tree in a forest is an organism.

All the individuals of a species living within a specific area are collectively called a **population**. Populations fluctuate based on a number of factors: seasonal and yearly changes in the environment, natural disasters such as forest fires and volcanic eruptions, and competition for resources between and within species. A **community** is the sum of populations inhabiting a particular area. For instance, all of the trees, insects, and other populations in a forest form the forest's community. The forest itself is an ecosystem.

An **ecosystem** consists of all the living things in a particular area together with the abiotic, non-living parts of that environment such as nitrogen in the soil or rain water. At the highest level of organization, the **biosphere** is the collection of all ecosystems, and it represents the zones of life on earth. It includes land, water, and even the atmosphere to a certain extent.

Life in an ecosystem is often about competition for limited resources, a characteristic of the process of natural selection. **Competition** in communities (all living things within specific habitats) is observed both within species and among different species. The resources for which organisms compete include organic material from living or previously living organisms, sunlight, and mineral nutrients, which provide the energy for living processes and the matter to make up organisms' physical structures. Other critical factors influencing community dynamics are the components of its physical and geographic environment: a habitat's latitude, amount of rainfall, topography (elevation), and available species. These are all important environmental variables that determine which organisms can exist within a particular area. Ecosystems can be small, such as the tidal pools found near the rocky shores of many oceans, or large, such as the Amazon Rainforest in Brazil (**Figure 1.4**).

There are three broad categories of ecosystems based on their general environment: freshwater, ocean water (marine), and terrestrial. Within these broad categories are individual ecosystem types based on the organisms present and the type of environmental habitat. Ocean ecosystems are the most common, comprising 75 percent of the Earth's surface. The shallow ocean ecosystems include extremely biodiverse coral reef ecosystems, and the deep ocean surface is known for its large numbers of plankton and krill (small crustaceans) that support it. These two

environments are especially important to aerobic respirators worldwide as the phytoplankton perform 40 percent of all photosynthesis on Earth. Although not as diverse as the other two, deep ocean ecosystems contain a wide variety of marine organisms. Such ecosystems exist even at the bottom of the ocean where light is unable to penetrate through the water.

Freshwater ecosystems are the rarest, occurring on only 1.8 percent of the Earth's surface. Lakes, rivers, streams, and springs comprise these systems; they are quite diverse, and they support a variety of fish, amphibians, reptiles, insects, phytoplankton, fungi, and bacteria.



(a) (b)

Figure 1.4. (a) A tidal pool ecosystem in Matinicus Island, Maine, is a small ecosystem, while (b) the Amazon rainforest in Brazil is a large ecosystem. (credit a: modification of work by Jim Kuhn; credit b: modification of work by Ivan Mlinaric)

Terrestrial ecosystems, also known for their diversity, are grouped into large categories called **biomes**, such as tropical rainforests, savannas, deserts, coniferous forests, deciduous forests, and tundra. Grouping these ecosystems into just a few biome categories obscures the great diversity of the individual ecosystems within them. For example, there is great variation in desert vegetation: the saguaro cacti and other plant life in the Sonoran Desert, in the United States, are relatively abundant compared to the desolate rocky desert of Boa Vista, an island off the coast of Western Africa.

All living things require energy in one form or another. It is important to understand how organisms acquire energy and how that energy is passed from one organism to another through **food webs**. Food webs illustrate how energy flows directionally through ecosystems, including how efficiently organisms acquire it, use it, and how much remains for use by other organisms of

the food web. The flow of energy and matter through the ecosystems influences the abundance and distribution of organisms within them.

Ecosystems are complex with many interacting parts. They are routinely exposed to various disturbances: changes in the environment that affect their compositions, such as yearly variations in rainfall and temperature. Many disturbances are a result of natural processes. For example, when lightning causes a forest fire and destroys part of a forest ecosystem, the ground is eventually populated with grasses, followed by bushes and shrubs, and later mature trees: thus, the forest is restored to its former state. This process is so universal that ecologists have given it a name—**succession**. The impact of environmental disturbances caused by human activities is now as significant as the changes wrought by natural processes. Human agricultural practices, air pollution, acid rain, global deforestation, overfishing, oil spills, and illegal dumping on land and into the ocean all have impacts on ecosystems.

We rely on ecosystem services. Earth's natural systems provide **ecosystem services** required for our survival such as: air and water purification, climate regulation, and plant pollination. We have degraded nature's ability to provide these services by depleting resources, destroying habitats, and generating pollution. The benefits people obtain from ecosystems include: nutrient cycling, soil formation, and **primary production**. Another important service of natural ecosystems is provisioning like food production, production of wood, fibers and fuel. Ecosystems are responsible for climate regulation, flood regulation together with disease regulation. Finally ecosystems provide cultural and esthetic services. As humans we benefit from observing natural habitats, recreation in waters and mountains. Nature is a source of inspiration for poets and writers. It is a source of aesthetic, religious and other nonmaterial benefits. Studying ecosystem structure in its original state is the only way we can make **anthropogenic** (man-made) systems like agricultural fields, reservoirs, fracking operations, and dammed rivers work for human benefit with minimal impact on our and other organisms' health.

Environment and environmental science

Viewed from space, Earth (**Figure 1.5**) offers no clues about the diversity of lifeforms that reside there. The first forms of life on Earth are thought to have been microorganisms that existed for billions of years in the ocean before plants and animals appeared. The mammals, birds, and plants so familiar to us are all relatively recent, originating 130 to 200 million years ago. Humans have inhabited this planet for only the last 2.5 million years, and only in the last 200,000 years have humans started looking like we do today. There are around 7.35 billion people today (https://www.census.gov/popclock/).



Figure 1.5 This NASA image is a composite of several satellite-based views of Earth. To make the whole-Earth image, NASA scientists combine observations of different parts of the planet. (credit: NASA/GSFC/NOAA/USGS)

The word **environment** describes living and nonliving surroundings relevant to organisms. It incorporates physical, chemical and biological factors and processes that determine the growth and survival of organisms, populations, and communities. All these components fit within the ecosystem concept as a way to organize all of the factors and processes that make up the environment. The ecosystem includes organisms and their environment within a specific area. Review the previous section for in-depth information regarding the Earth's ecosystems. Today, human activities influence all of the Earth's ecosystems.

Environmental science studies all aspects of the environment in an **interdisciplinary** way. This means that it requires the knowledge of various other subjects including biology, chemistry, physics, statistics, microbiology, biochemistry, geology, economics, law, sociology, etc. It is a relatively new field of study that has evolved from integrated use of many disciplines. **Environmental engineering** is one of the fastest growing and most complex disciplines of engineering. Environmental engineers solve problems and design systems using knowledge of environmental concepts and ecology, thereby providing solutions to various environmental problems. **Environmentalism**, in contrast, is a social movement through which citizens are involved in activism to further the protection of environmental landmarks and natural resources. This is not a field of science, but incorporates some aspects of environmental knowledge to advance conservation and sustainability efforts.

The Process of Science

Environmental science is a science, but what exactly is science? **Science** (from the Latin *scientia*, meaning "knowledge") can be defined as all of the fields of study that attempt to comprehend the nature of the universe and all its parts. The **scientific method** is a method of research with defined steps that include experiments and careful observation. One of the most important aspects of this method is the testing of hypotheses by means of repeatable experiments. A **hypothesis** is a suggested explanation for an event, which can be tested. A **theory** is a tested and confirmed explanation for observations or phenomena that is supported by many repeated experiences and observations.

The scientific method

The scientific process typically starts with an observation (often a problem to be solved) that leads to a question. The scientific method consists of a series of well-defined steps. If a hypothesis is not supported by experimental data, a new hypothesis can be proposed. Let's think about a simple problem that starts with an observation and apply the scientific method to solve the problem. One Monday morning, a student arrives in class and quickly discovers that the classroom is too warm. That is an observation that also describes a problem: the classroom is too warm. The student then asks a question: "Why is the classroom so warm?"

Proposing a Hypothesis

Recall that a hypothesis is a suggested explanation that can be tested. To solve a problem, several hypotheses may be proposed. For example, one hypothesis might be, "The classroom is warm because no one turned on the air conditioning." But there could be other responses to the question, and therefore other hypotheses may be proposed. A second hypothesis might be, "The classroom is warm because there is a power failure, and so the air conditioning doesn't work." Once a hypothesis has been selected, the student can make a prediction. A prediction is similar to a hypothesis but it typically has the format "If . . . then . . . ." For example, the prediction for the first hypothesis might be, "*If* the student turns on the air conditioning, *then* the classroom will no longer be too warm."

Testing a Hypothesis

A valid hypothesis must be testable. It should also be falsifiable, meaning that it can be disproven by experimental results. Importantly, science does not claim to "prove" anything because scientific understandings are always subject to modification with further information. This step — openness to disproving ideas — is what distinguishes sciences from non-sciences. The presence of the supernatural, for instance, is neither testable nor falsifiable.

To test a hypothesis, a researcher will conduct one or more **experiments** designed to eliminate, or disprove, the hypotheses. Each experiment will have one or more variables and one or more controls. A **variable** is any part of the experiment that can vary or change during the experiment. The **independent variable** is the variable that is manipulated throughout the course of the

experiment. The **dependent variable**, or response variable is the variable by which we measure change in response to the independent variable. Ideally, all changes that we measure in the dependent variable are because of the manipulations we made to the independent variable. In most experiments, we will maintain one group that has had no experimental change made to it. This is the **control group**. It contains every feature of the **experimental group** except it is not given any manipulation. Therefore, if the results of the experimental group differ from the control group, the difference must be due to the hypothesized manipulation, rather than some outside factor. Look for the variables and controls in the examples that follow.

To test the hypothesis "*The classroom is warm because no one turned on the air conditioning*," the student would find out if the air conditioning is on. If the air conditioning is turned on but does not work, there should be another reason, and this hypothesis should be rejected. To test the second hypothesis, the student could check if the lights in the classroom are functional. If so, there is no power failure and this hypothesis should be rejected. Each hypothesis should be tested by carrying out appropriate experiments. Be aware that rejecting one hypothesis does not determine whether or not the other hypotheses can be accepted; it simply eliminates one hypothesis that is not valid (**Figure 1.7**). Using the scientific method, the hypotheses that are inconsistent with experimental data are rejected.

The scientific method may seem too rigid and structured. It is important to keep in mind that, although scientists often follow this sequence, there is flexibility. Sometimes an experiment leads to conclusions that favor a change in approach; often, an experiment brings entirely new scientific questions to the puzzle. Many times, science does not operate in a linear fashion; instead, scientists continually draw inferences and make generalizations, finding patterns as their research proceeds. Scientific reasoning is more complex than the scientific method alone suggests. Notice, too, that the scientific method can be applied to solving problems that aren't necessarily scientific in nature.

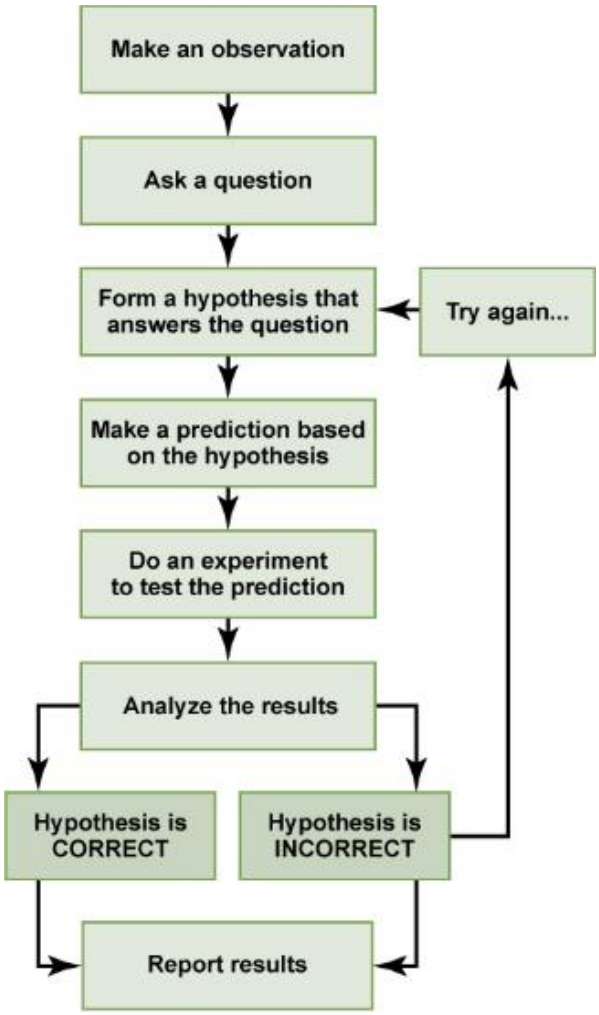


Figure 1.7. The scientific method consists of a series of well-defined steps. If a hypothesis is not supported by experimental data, a new hypothesis can be proposed.

Sustainability and Sustainable Development

In 1983 the United Nations General Assembly passed a resolution that established the Special Commission on the Environmental Perspective to the Year 2000 and Beyond (http://www.un.org/documents/ga/res/38/a38r161.htm). Their charge was:

a. To propose long-term environmental strategies for achieving sustainable development to the year 2000 and beyond;
b. To recommend ways in which concern for the environment may be translated into greater co-operation among developing countries and between countries at different stages of economic and social development and lead to the achievement of common and mutually supportive objectives which take account of the interrelationships between people, resources, environment and development;

c. To consider ways and means by which the international community can deal more effectively with environmental concerns, in light of the other recommendations in its report;
d. To help define shared perceptions of long-term environmental issues and of the appropriate efforts needed to deal successfully with the problems of protecting and enhancing the environment, a long-term agenda for action during the coming decades, and aspirational goals for the world community, taking into account the relevant resolutions of the session of a special character of the Governing Council in 1982.

Although the report did not technically invent the term **sustainability**, it was the first credible and widely disseminated study that used this term in the context of the global impacts of humans on the environment. Its main and often quoted definition refers to **sustainable development** as *development that meets the needs of the present without compromising the ability of future generations to meet their own needs*. The report uses the terms 'sustainable development', 'sustainable', and 'sustainability' interchangeably, emphasizing the connections among social equity, economic productivity, and environmental quality (**Figure 1.6**). This three-pronged approach to sustainability is now commonly referred to as the **triple bottom-line**. Preserving the environment for humans today and in the future is a responsibility of every generation and a long-term global goal. Sustainability and the triple bottom-line (meeting environmental, economic, and social goals simultaneously) require that we limit our environmental impact, while promoting economic well-being and social equity.

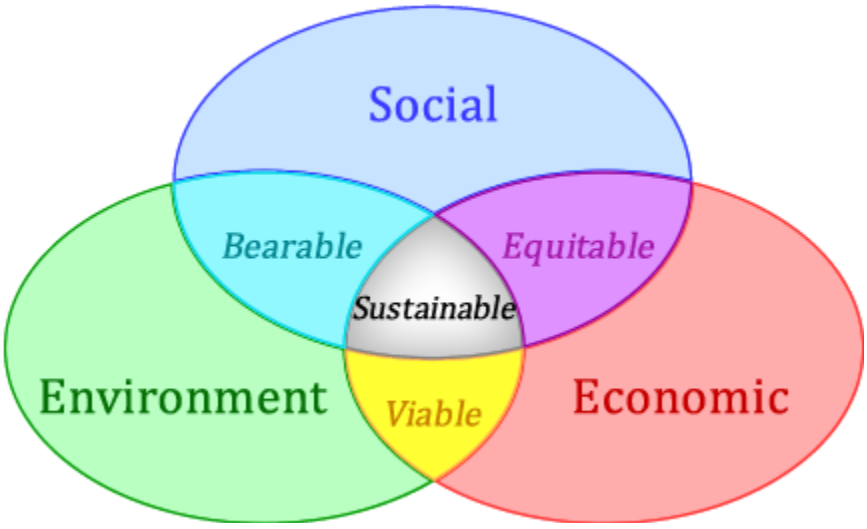


Figure 1.6. A depiction of the sustainability paradigm in terms of its three main components, showing various intersections among them. Source: International Union for the Conservation of Nature.

Examples of sustainable development include sustainable agriculture, which is agriculture that does not deplete soils faster than they form and does not destroy the biodiversity of the area. Sustainable farming and ranching do not reduce the amount of healthy soil, clean water, genetic diversity of crop plants and animals. Maintaining as much ecological **biodiversity** as possible in the agro-ecosystem is essential to long-term crop and livestock production.

The IPAT Equation

As attractive as the concept of sustainability may be as a means of framing our thoughts and goals, its definition is rather broad and difficult to work with when confronted with choices among specific courses of action. One way of measuring progress toward achieving sustainable goals can be with the application of the **IPAT equation**. This equation was designed in an attempt to define the different ways that a variety of factors contribute to the environmental degradation, or impact, of a particular setting. Importantly, IPAT tells us that there are more ways we impact our environment than just through pollution:

$$I = P \times A \times T$$

I represents the impacts on an environment
P is the size of the relevant human population
A is the affluence of the population
T is the technology available to the population

Affluence, or wealth, tells us the level of consumption per person. Wealthy societies consume more goods and services per person. Because of this, their environmental impact is multiplied. Technology, or impact per unit of consumption, interpreted in its broadest sense. This includes any human-created tool, system, or organization designed to enhance efficiency. As societies gain greater access to technology, they are able to do more work with fewer individuals. This equates to a greater impact per person. While this equation is not meant to be mathematically rigorous, it provides a way of organizing information for analysis.

The proportion of people living in cities has greatly increased over the past 50 years. We can use the IPAT equation to estimate the impact of these urban populations. When the impact of technology, which is much easier to access in urban settings, is combined with the impact of population, the impact on the environment is multiplied. In an increasingly urban world, we must focus much of our attention on the environments of cities and on the effects of cities on the rest of the environment. This equation also has large-scale applications in the environmental sciences, and was included in the Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios (2001) to project future greenhouse gas emissions across the globe.

The precautionary principle

The **precautionary principle** or the precautionary approach is one perspective of environmental risk management. The precautionary principle stakes that "When the health of humans and the environment is at stake, it may not be necessary to wait for scientific certainty to take protective action". In other words, better to be safe than sorry. Proponents of the precautionary principle also believe that the burden of proof should be on the individual, company or government who is proposing the action, not on the people who will be affected by it. For example, if environmental regulations concerning pesticides were based on the precautionary principle (in the United States, they are not), then any pesticide that could potentially harm the environment or human health would not be used. Overuse of the precautionary principle can have negative consequences as well. If federal regulations concerning medicines for human use were based on the precautionary principle (again, in the United States, they are not), then any medicine that could potentially harm any person would not be used. This would effectively ban nearly all medical trials leading to new medications.

What is the environment worth to you?

The environment, and its benefits to individuals or groups, can be viewed and justified from multiple perspectives. A **utilitarian justification** for environmental conservation means that we should protect the environment because doing so provides a direct economic benefit to people. For example, someone might propose not developing Georgia's coastal salt marshes because the young of many commercial fishes live in salt marshes and the fishers will collapse without this habitat. An **ecological justification** for environmental conservation means that we should protect the environmental because doing so will protect both species that are beneficial to other as well as other species and an ecological justification for conservation acknowledges the many ecosystem services that we derive from healthy ecosystems. For example, we should protect Georgia's coastal salt marshes because salt marshes purify water, salt marshes are vital to the survival of many marine fishes and salt marshes protect our coasts from storm surges. An **aesthetic justification** for conservation acknowledges that many people enjoy the outdoors and do not want to live in a world without wilderness. One could also think of this as recreational, inspirational, or spiritual justification for conservation. For example, salt marshes are beautiful places and I always feel relaxed and calm when I am visiting one, therefore we should protect salt marches. And finally a **moral justification** represents the belief that various aspects of the environment have a right to exist and that it is our moral obligation to allow them to continue or help them persist. Someone who was arguing for conservation using a moral justification would say that it is wrong to destroy the coastal salt marshes.

Global perspective

The solution to most environmental problems requires a global perspective. Human population size has now reached a scale where the environmental impacts are global in scale and will require multilateral solutions. You will notice this theme continue as you move through the next seven chapters of this text. As you do so, keep in mind that the set of environmental, regulatory, and economic circumstances common in the United States are not constant throughout the world. Be ready to investigate environmental situations and problems from a diverse set of viewpoints throughout this semester.

Parts of this chapter have been modified from the OpenStax textbooks.

Study questions

1. Why there was a need to study the impact of human population growth on the environment?
2. What does sustainability mean to you?
3. What are the consequences of unsustainable vs. sustainable living? What impacts do these have on quality of life do we want for us and future generations?
4. Think of an environmental problem that requires a global perspective for a solution. How might this problem be examined from a variety of environmental justification perspectives?

Websites for more information and further discussion

Information about the field of environmental science: http://www.environmentalscience.org/
"Process" of science http://undsci.berkeley.edu/

Terms list

Adenosine triphosphate
Aesthetic justification
Amino acid
Anthropogenic
Atom
ATP
Biome
Biosphere
Carbohydrate
Cellular respiration
Community
Competition
Control group
Denature
Deoxyribonucleic acid
Dependent variable
DNA
Ecological justification
Ecosystem
Ecosystem service
Electron
Element
Environment
Environmental engineering
Environmental science
Environmentalism
Experiment
Experimental group
Food web
Glucose
Hydrocarbon
Hypothesis
Independent variable
Interdisciplinary
Ion
IPAT equation
Isotope
Lipid
Matter
Molecule
Moral justification
Neutron
Nucleic acid
Nucleus
Organelle
Organic molecule
Organism
Population
Precautionary principle
Primary production
Protein
Proton
Radioisotope
Ribonucleic acid
RNA
Science
Scientific method
Starch
Succession
Sustainability
Sustainable development
Theory
Tripe bottom-line
Utilitarian justification
Variable

Chapter 2: Population Ecology



A population of elephants at Pinnewala Elephant Orphanage, Sri Lanka. Photo by Paginazero, Wikimedia commons.



A shoal of anchovies in Liguria, Italy. Photo by Alessandro Duci. Wikimedia commons.

Learning Outcomes - At the end of this, chapter students will be able to:

- Define the variables in the exponential and logistic growth equations.
- Use the exponential and logistic equations to predict population growth rate.
- Compare the environmental conditions represented by the exponential growth model vs. the logistic growth model.
- Define carrying capacity and be able to label the carrying capacity on a graph.
- Compare density-dependent and density-independent factors that limit population growth and give examples of each.
- Interpret survivorship curves and give examples of organisms that would fit each type of curve.

Chapter outline

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2.4 Life Tables and Survivorship 9

2.1 Population Ecology

Ecology is a sub-discipline of biology that studies the interactions between organisms and their environments. A group of interbreeding individuals (individuals of the same species) living and interacting in a given area at a given time is defined as a **population**. These individuals rely on the same resources and are influenced by the same environmental factors. **Population ecology,** therefore, is the study of how individuals of a particular species interact with their environment and change over time. The study of any population usually begins by determining how many individuals of a particular species exist, and how closely associated they are with each other. Within a particular habitat, a population can be characterized by its **population size** (***N***), defined by the total number of individuals, and its **population density**, the number of individuals of a particular species within a specific area or volume (units are number of individuals/unit area or unit volume). Population *size* and *density* are the two main characteristics used to describe a population. For example, larger populations may be more stable and able to persist better than smaller populations because of the greater amount of genetic variability, and their potential to adapt to the environment or to changes in the environment. On the other hand, a member of a population with low population density (more spread out in the habitat), might have more difficulty finding a mate to reproduce compared to a population of higher density. Other characteristics of a population include **dispersion** – the way individuals are spaced within the area; **age structure** – number of individuals in different age groups and; **sex ratio** – proportion of males to females; and growth – change in population size (increase or decrease) over time.

2.2 Population Growth Models

Populations change over time and space as individuals are born or immigrate (arrive from outside the population) into an area and others die or emigrate (depart from the population to another location). Populations grow and shrink and the age and gender composition also change through time and in response to changing environmental conditions. Some populations, for example trees in a mature forest, are relatively constant over time while others change rapidly. Using idealized models, population ecologists can predict how the size of a particular population will change over time under different conditions.

2.2.1 Exponential Growth

Charles Darwin, in his theory of natural selection, was greatly influenced by the English clergyman Thomas Malthus. Malthus published a book (An Essay on the Principle of Population) in 1798 stating that populations with unlimited natural resources grow very rapidly. According to the Malthus' model, once population size exceeds available resources, population growth decreases dramatically. This accelerating pattern of increasing population size is called **exponential growth,** meaning that the population is increasing by a fixed percentage each year. When plotted (visualized) on a graph showing how the population size increases over time, the result is a J-shaped curve (**Figure 2.1**). Each individual in the population reproduces by a certain amount (***r***) and as the population gets larger, there are more individuals reproducing by that same amount (the fixed percentage). In nature, exponential growth only occurs if there are no external limits.

One example of exponential growth is seen in bacteria. Bacteria are prokaryotes (organisms whose cells lack a nucleus and membrane-bound organelles) that reproduce by fission (each individual cell splits into two new cells). This process takes about an hour for many bacterial species. If 100 bacteria are placed in a large flask with an unlimited supply of nutrients (so the nutrients will not

become depleted), after an hour, there is one round of division and each organism divides, resulting in 200 organisms - an increase of 100. In another hour, each of the 200 organisms divides, producing 400 - an increase of 200 organisms. After the third hour, there should be 800 bacteria in the flask - an increase of 400 organisms. After ½ a day and 12 of these cycles, the population would have increased from 100 cells to more than 24,000 cells. When the population size, *N*, is plotted over time, a J-shaped growth curve is produced (**Figure 2.1**). This shows that the number of individuals added during each reproduction generation is accelerating – increasing at a faster rate.

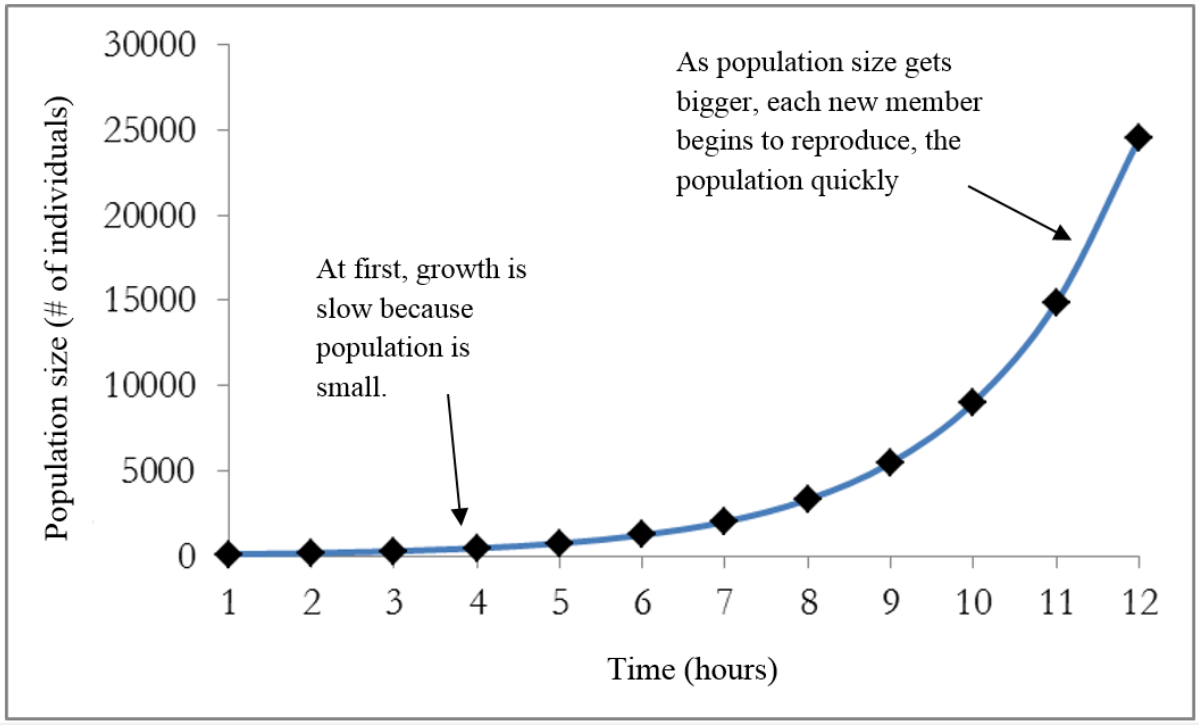


Figure 2.1: The "J" shaped curve of exponential growth for a hypothetical population of bacteria. The population starts out with 100 individuals and after 11 hours there are over 24,000 individuals. As time goes on and the population size increases, the rate of increase also increases (each step up becomes bigger). In this figure "r" is positive.

This type of growth can be represented using a mathematical function known as the **exponential growth model:**

G* = *r* x *N (also expressed as ***dN/dt* = *r* x *N***). In this equation

G (or ***dN/dt***) is the *population growth rate*, it is a measure of the number of individuals added per time interval time.

r is the *per capita rate of increase* (the average contribution of each member in a population to population growth; per capita means "per person").

N is the *population size*, the number of individuals in the population at a particular time.

Per capita rate of increase (r)

In exponential growth, the *population growth rate* (***G***) depends on population size (*N*) and the per capita rate of increase (*r*). In this model *r* does not change (fixed percentage) and change in population growth rate, **G**, is due to change in population size, ***N***. As new individuals are added to the population, each of the new additions contribute to population growth at the same rate (*r*) as the individuals already in the population.

r = (birth rate + immigration rate) – (death rate and emigration rate).

If *r* is positive (> zero), the population is increasing in size; this means that the birth and immigration rates are greater than death and emigration.

If *r* is negative (< zero), the population is decreasing in size; this means that the birth and immigration rates are less than death and emigration rates.

If *r* is zero, then the population growth rate (***G***) is zero and population size is unchanging, a condition known as zero population growth. "***r***" varies depending on the type of organism, for example a population of bacteria would have a much higher "***r***" than an elephant population. In the exponential growth model r is multiplied by the population size, *N*, so population growth rate is largely influenced by *N*. This means that if two populations have the same per capita rate of increase (*r*), the population with a larger *N* will have a larger population growth rate than the one with a smaller *N*.

2.2.2 Logistic Growth

Exponential growth cannot continue forever because resources (food, water, shelter) will become limited. Exponential growth may occur in environments where there are few individuals and plentiful resources, but soon or later, the population gets large enough that individuals run out of vital resources such as food or living space, slowing the growth rate. When resources are limited, populations exhibit **logistic growth.** In logistic growth a population grows nearly exponentially at first when the population is small and resources are plentiful but growth rate slows down as the population size nears limit of the environment and resources begin to be in short supply and finally stabilizes (zero population growth rate) at the maximum population size that can be supported by the environment (**carrying capacity**). This results in a characteristic S-shaped growth curve (**Figure 2.2**). The mathematical function or logistic growth model is represented by the following equation:

$$\boldsymbol{G = r * N * [1 - \frac{N}{K}]}$$

Where,
K is the *carrying capacity* – the maximum population size that a particular environment can sustain ("carry"). Notice that this model is similar to the exponential growth model except for the addition of the carrying capacity.

In the exponential growth model, population growth rate was mainly dependent on *N* so that each new individual added to the population contributed equally to its growth as those individuals previously in the population because per capita rate of increase is fixed. In the logistic growth model, individuals' contribution to population growth rate depends on the amount of resources available (K). As the number of individuals (N) in a population increases, fewer resources are available to each

individual. As resources diminish, each individual on average, produces fewer offspring than when resources are plentiful, causing the birth rate of the population to decrease.

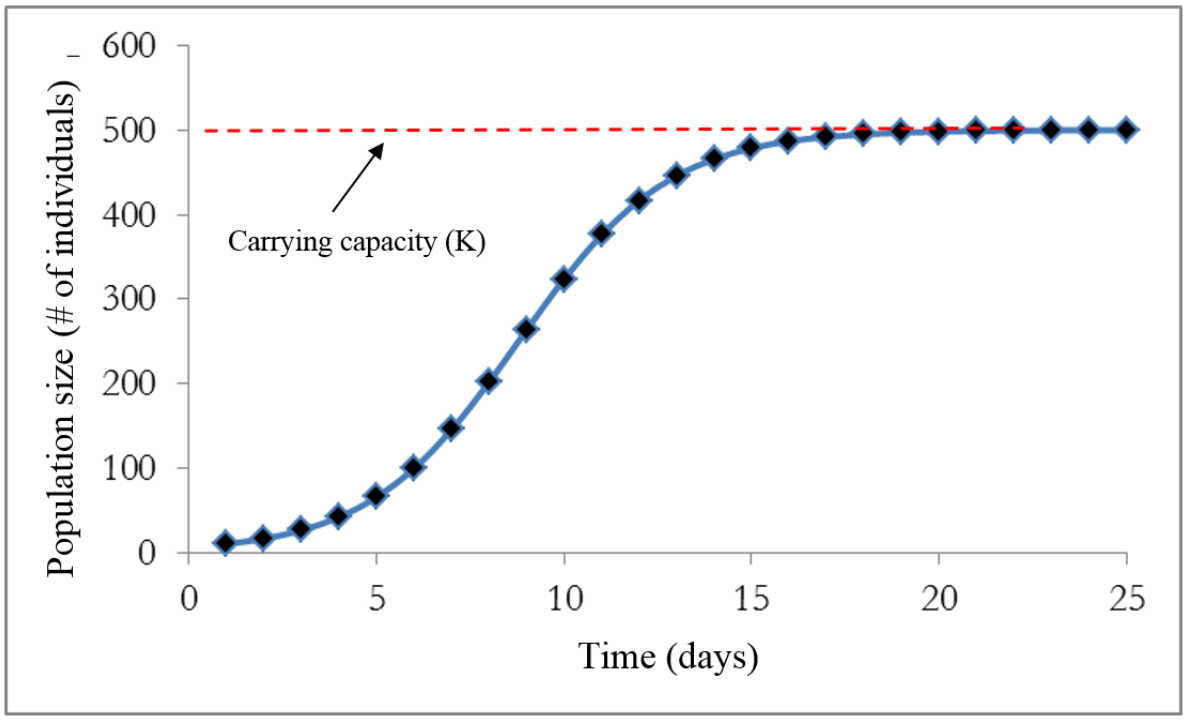


Figure 2.2: Shows logistic growth of a hypothetical bacteria population. The population starts out with 10 individuals and then reaches the carrying capacity of the habitat which is 500 individuals.

Influence of *K* on population growth rate

In the logistic growth model, the exponential growth (***r * N***) is multiplied by fraction or expression that describes the effect that limiting factors (***1 - N/K***) have on an increasing population. Initially when the population is very small compared to the capacity of the environment (*K*), 1 - N/K is a large fraction that nearly equals 1 so population growth rate is close to the exponential growth (r * N). For example, supposing an environment can support a maximum of 100 individuals and N = 2, N is so small that *1 – N/K* (1 – 2/100 = 0.98) will be large, close to 1. As the population increases and population size gets closer to carrying capacity (N nearly equals K), then 1 - N/K is a small fraction that nearly equals zero and when this fraction is multiplied by r * N, population growth rate is slowed down. In the earlier example, if the population grows to 98 individuals, which is close to (but not equal) K, then 1 – N/K (1 – 98/100 = 0.02) will be so small, close to zero. If population size equals the carrying capacity, N/K = 1, so 1 – N/K = 0, population growth rate will be zero (in the above example, 1 – 100/100 = 0). This model, therefore, predicts that *a population's growth rate will be small when the population size is either small or large, and highest when the population is at an intermediate level relative to K*. At small populations, growth rate is limited by the small amount of individuals (*N*) available to reproduce and contribute to population growth rate whereas at large populations, growth rate is limited by the limited amount of resources available to each of the large number of individuals to enable them reproduce successfully. In fact, *maximum population growth rate* ***(G)*** *occurs when N is half of K*.

Yeast is a microscopic fungus, used to make bread and alcoholic beverages, that exhibits the classical S-shaped logistic growth curve when grown in a test tube (**Figure 2.3**). Its growth levels off as the population depletes the nutrients that are necessary for its growth. In the real world, however, there are variations to this idealized curve. For example, a population of harbor seals may exceed the carrying capacity for a short time and then fall below the carrying capacity for a brief time period and as more resources become available, the population grows again (**Figure 2.4**). This fluctuation in population size continues to occur as the population oscillates around its carrying capacity. Still, even with this oscillation, the logistic model is exhibited.

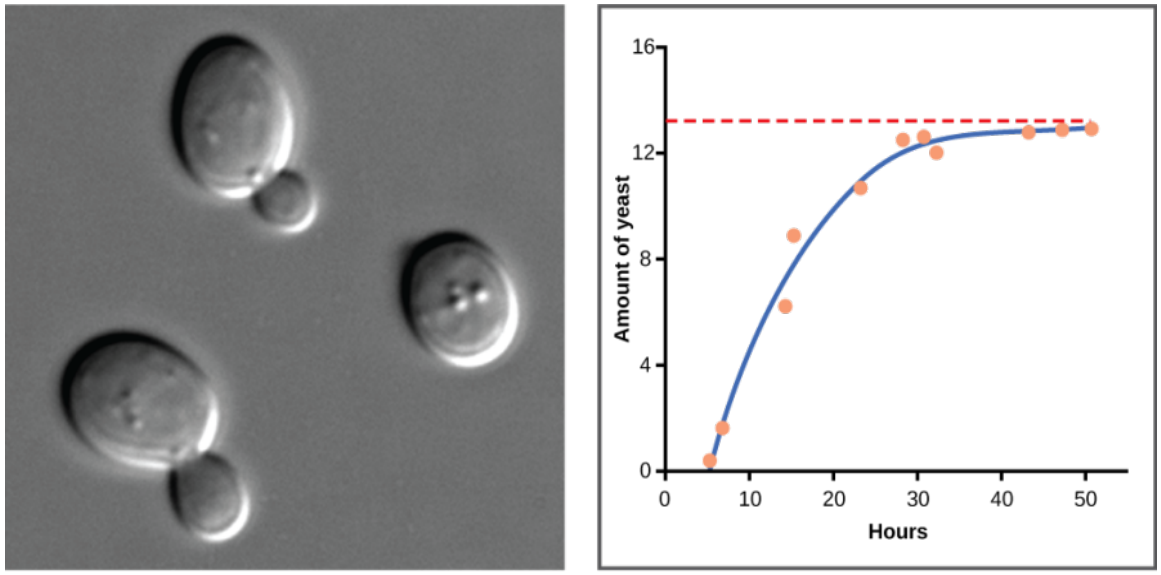


Figure 2.3: Graph showing amount of yeast versus time of growth in hours. The curve rises steeply, and then plateaus at the carrying capacity. Data points tightly follow the curve. The image is a micrograph (microscope image) of yeast cells

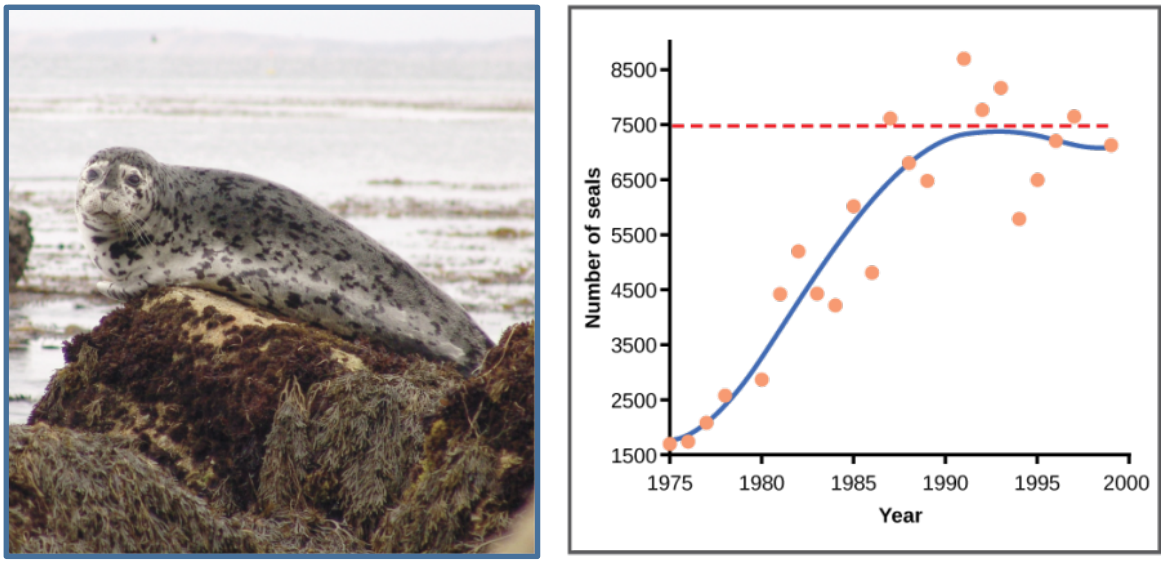


Figure 2.4: Graph showing the number of harbor seals versus time in years. The curve rises steeply then plateaus at the carrying capacity, but this time there is much more scatter in the data. A photo of a harbor seal is shown.

2.3 Factors limiting population growth

Recall previously that we defined density as the number of individuals per unit area. In nature, a population that is introduced to a new environment or is rebounding from a catastrophic decline in numbers may grow exponentially for a while because density is low and resources are not limiting. Eventually, one or more environmental factors will limit its population growth rate as the population size approaches the carrying capacity and density increases. Example: imagine that in an effort to preserve elk, a population of 20 individuals is introduced to a previously unoccupied island that's 200 km^2 in size. The population density of elk on this island is 0.1 elk/km^2 (or 10 km^2 for each individual elk). As this population grows (depending on its per capita rate of increase), the number of individuals increases but the amount of space does not so density increases. Suppose that 10 years later, the elk population has grown to 800 individuals, density = 4 elk/ km^2 (or 0.25 km^2 for each individual). The population growth rate will be limited by various factors in the environment. For example, birth rates may decrease due to limited food or death rate increase due to rapid spread of disease as individuals encounter one another more often. This impact on birth and death rate in turn influences the per capita rate of increase and how the population size changes with changes in the environment. When birth and death rates of a population change as the density of the population changes, the rates are said to be density-dependent and the environmental factors that affect birth and death rates are known as **density-dependent factors**. In other cases, populations are held in check by factors that are not related to the density of the population and are called **density-independent factors** and influence population size regardless of population density. Conservation biologists want to understand both types because this helps them manage populations and prevent extinction or overpopulation.

The density of a population can enhance or diminish the impact of *density-dependent* factors. Most density-dependent factors are *biological* in nature (biotic), and include such things as predation, inter- and intraspecific competition for food and mates, accumulation of waste, and diseases such as those caused by parasites. Usually, higher population density results in higher death rates and lower birth rates. For example, as a population increases in size food becomes scarcer and some individuals will die from starvation meaning that the death rate from starvation increases as population size increases. Also as food becomes scarcer, birth rates decrease due to fewer available resources for the mother meaning that the birth rate decreases as population size increases. For density-dependent factors, there is a feedback loop between population density and the density-dependent factor.

Two examples of density-dependent regulation are shown in **Figure 2.5**. First one is showing results from a study focusing on the giant intestinal roundworm (*Ascaris lumbricoides*), a parasite that infects humans and other mammals. Denser populations of the parasite exhibited lower fecundity (number of eggs per female). One possible explanation for this is that females would be smaller in more dense populations because of limited resources and smaller females produce fewer eggs.

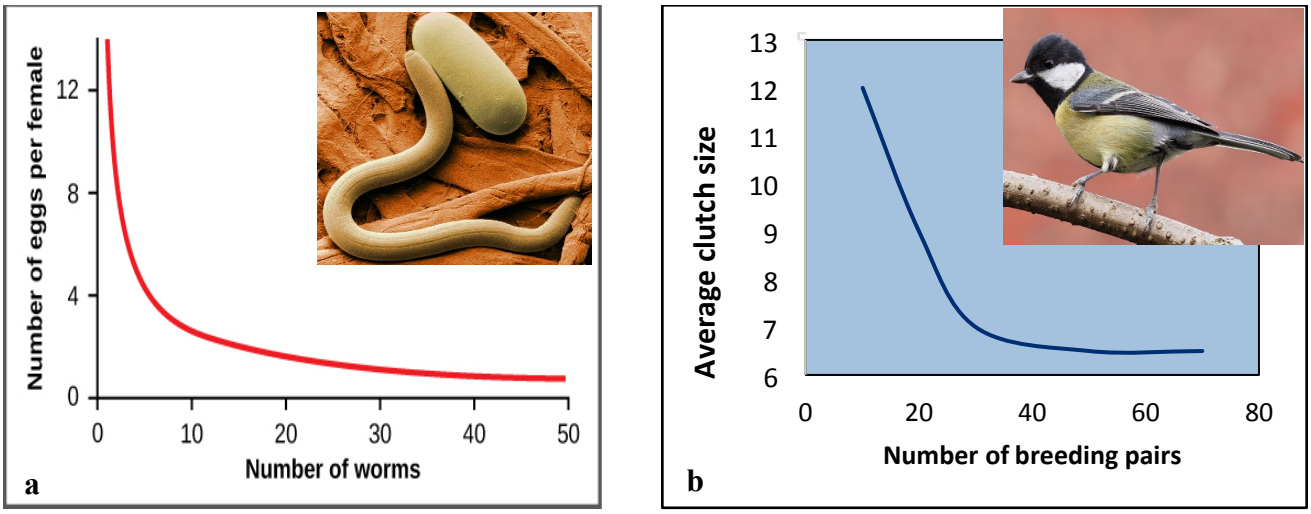


Figure 2.5: (**a**) Graph of number of eggs per female (fecundity), as a function of population size. In this population of roundworms, fecundity (number of eggs) decreases with population density. (**b**) Graph of clutch size (number of eggs per "litter") of the great tits bird as a function of population size (breeding pairs). Again, clutch size decreases as population density increases. (Photo credits: Worm image from Wikimedia commons, public domain image; bird image from Wikimedia commons, photo by Francis C. Franklin / CC-BY-SA-3.0)

Density-independent birth rates and death rates do NOT depend on population size; these factors are independent of, or not influenced by, population density. Many factors influence population size regardless of the population density, including weather extremes, natural disasters (earthquakes, hurricanes, tornadoes, tsunamis, etc.), pollution and other physical/abiotic factors. For example, an individual deer may be killed in a forest fire regardless of how many deer happen to be in the forest. The forest fire is not responding to deer population size. As the weather grows cooler in the winter, many insects die from the cold. The change in weather does not depend on whether there is a population size of 100 mosquitoes or 100,000 mosquitoes, most mosquitoes will die from the cold regardless of the population size and the weather will change irrespective of mosquito population density. Looking at the growth curve of such a population would show something like an exponential growth followed by a rapid decline rather than levelling off (**Figure 2.6**).

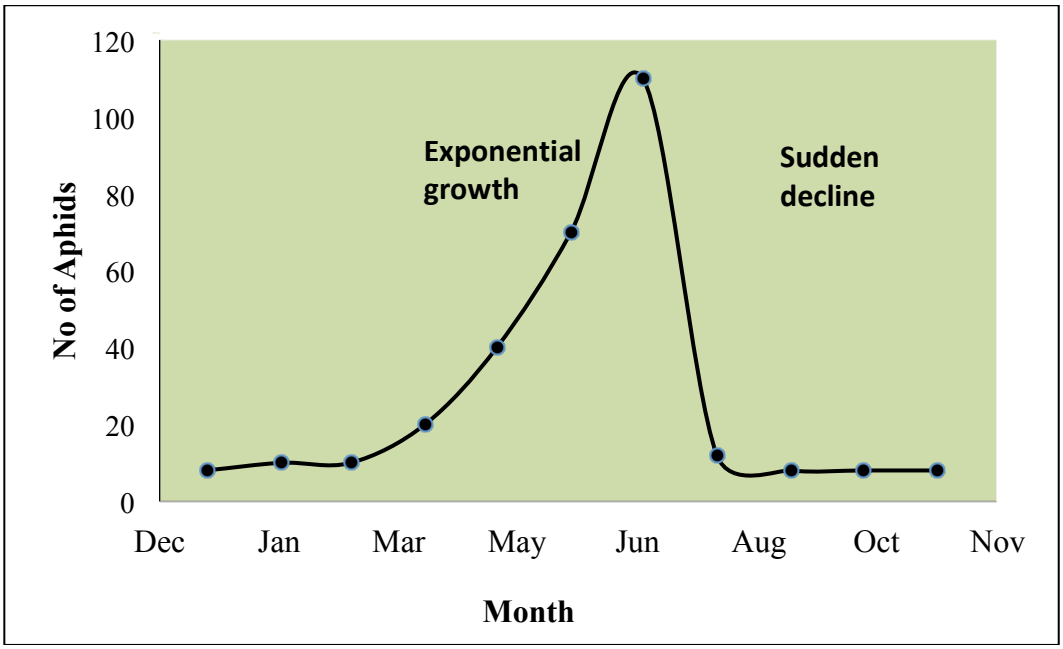


Figure 2.6: Weather change acting as a density-independent factor limiting aphid population growth. This insect undergoes exponential growth in the early spring and then rapidly die off when the weather turns hot and dry in the summer

In real-life situations, density-dependent and independent factors interact. For example, a devastating earthquake occurred in Haiti in 2010. This earthquake was a natural geologic event that caused a high human death toll from this *density-independent event*. Then there were high densities of people in refugee camps and the high density caused disease to spread quickly, representing a *density-dependent* death rate.

Q: Can you think of other *density-dependent* (biological) and *density-independent* (abiotic) population limiting factors?

2.4 Life Tables and Survivorship

Population ecologists use life tables to study species and identify the most vulnerable stages of organisms' lives to develop effective measures for maintaining viable populations. Life tables, like **Table 2.1**, track **survivorship**, the chance of an individual in a given population surviving to various ages. Life tables were invented by the insurance industry to predict how long, on average, a person will live. Biologists use a life table as a quick window into the lives of the individuals of a population, showing how long they are likely to live, when they'll reproduce, and how many offspring they'll produce. Life tables are used to construct **survivorship curves**, which are graphs showing the proportion of individuals of a particular age that are now alive in a population. Survivorship (chance of surviving to a particular age) is plotted on the y-axis as a function of age or time on the x-axis. However, if the percent of maximum lifespan is used on the x-axis instead of actual ages, it is possible to compare survivorship curves for different types of organisms (**Figure 2.7**). All survivorship curves start along the y-axis intercept with all of the individuals in the population (or 100% of the individuals

surviving). As the population ages, individuals die and the curves goes down. A survivorship curve never goes up.

Table 2.1: Life Table for the U.S. population in 2011 showing the number who are expected to be alive at the beginning of each age interval based on the death rates in 2011. For example, 95,816 people out of 100,000 are expected to live to age 50 (0.983 chance of survival). The chance of surviving to age 60 is 0.964 but the chance of surviving to age 90 is only 0.570.

Age (years)	Number Living at Start of Age Interval	Number Dying During Interval	Chance of Surviving Interval	Chance of Dying During Interval
0-1	100000	606	0.993942	0.006058
1-5	99394	105	0.998946	0.001054
5-10	99289	60	0.999397	0.000603
10-15	99230	70	0.999291	0.000709
15-20	99159	242	0.997562	0.002438
20-25	98917	425	0.995704	0.004296
25-30	98493	475	0.995176	0.004824
30-35	98017	553	0.994362	0.005638
35-40	97465	681	0.993015	0.006985
40-45	96784	968	0.989994	0.010006
45-50	95816	1535	0.983982	0.016018
50-55	94281	2306	0.975541	0.024459
55-60	91975	3229	0.964895	0.035105
60-65	88746	4378	0.950668	0.049332
65-70	84368	6184	0.926698	0.073302
70-75	87184	8670	0.889101	0.110899
75-80	69513	12021	0.827073	0.172927
80-85	57493	15760	0.725879	0.274121
85-90	41733	17935	0.570241	0.429759
90-95	23798	14701	0.382258	0.617742
95-100	9097	7169	0.211924	0.788076
100 and over	1928	1928	0	1.000000

SOURCE: CDC/NCHS, National Vital Statistics System.

Survivorship curves reveal a huge amount of information about a population, such as whether most offspring die shortly after birth or whether most survive to adulthood and likely to live long lives. They generally fall into one of three typical shapes, Types I, II and III (**Figure 2.7a**). Organisms that exhibit **Type I** survivorship curves have the highest probability of surviving every age interval until old age, then the risk of dying increases dramatically. Humans are an example of a species with a Type I survivorship curve. Others include the giant tortoise and most large mammals such as elephants. These organisms have few natural predators and are, therefore, likely to live long lives. They tend to produce only a few offspring at a time and invest significant time and effort in each offspring, which increases survival.

In the **Type III** survivorship curve most of the deaths occur in the youngest age groups. Juvenile survivorship is very low and many individuals die young but individuals lucky enough to survive the first few age intervals are likely to live a much longer time. Most plants species, insect

species, frogs as well as marine species such as oysters and fishes have a Type III survivorship curve. A female frog may lay hundreds of eggs in a pond and these eggs produce hundreds of tadpoles. However, predators eat many of the young tadpoles and competition for food also means that many tadpoles don't survive. But the few tadpoles that do survive and metamorphose into adults then live for a relatively long time (for a frog). The mackerel fish, a female is capable of producing a million eggs and on average only about 2 survive to adulthood. Organisms with this type of survivorship curve tend to produce very large numbers of offspring because most will not survive. They also tend not to provide much parental care, if any.

Type II survivorship is intermediate between the others and suggests that such species have an even chance of dying at any age. Many birds, small mammals such as squirrels, and small reptiles, like lizards, have a Type II survivorship curve. The straight line indicates that the proportion alive in each age interval drops at a steady, regular pace. The likelihood of dying in any age interval is the same.

In reality, most species don't have survivorship curves that are definitively type I, II, or III. They may be anywhere in between. These three, though, represent the extremes and help us make predictions about reproductive rates and parental investment without extensive observations of individual behavior. For example, humans in less industrialized countries tend to have higher mortality rates in all age intervals, particularly in the earliest intervals when compared to individuals in industrialized countries. Looking at the population of the United States in 1900 (**Figure 2.7b**), you can see that mortality was much higher in the earliest intervals and throughout, the population seemed to exhibit a type II survivorship curve, similar to what might be seen in less industrialized countries or amongst the poorest populations.

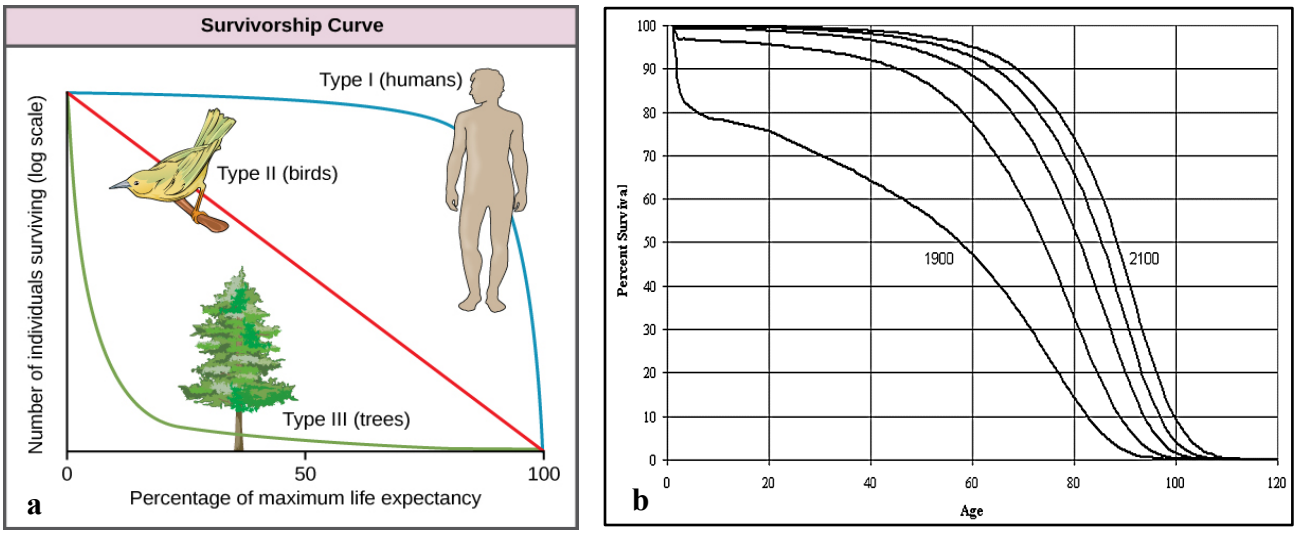


Figure 2.7: (**a**) Survivorship curves show the distribution of individuals in a population according to age. Humans and most large mammals have a Type I survivorship curve because most death occurs in the older years. Birds have a Type II survivorship curve, as death at any age is equally probable. Trees have a Type III survivorship curve because very few survive the younger years, but after a certain age, individuals are much more likely to survive. (**b**) Survivoship curves for the US population for 1900, 1950, 2000, 2050, 2100 *SOURCE: www.ssa.gov*.

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This material has been modified from the OpenStax Biology textbook.

POPULATION ECOLOGY PRACTICE PROBLEMS

1. If a population is experiencing exponential growth, what happens to **N**, ***r*** and **G** over time (increase, decrease or stay the same)?

2. At the beginning of the year, there are 7650 individuals in a population of beavers whose per capita rate of increase for the year is 0.18. What is its population growth rate at the end of the year?

3. A zebrafish population of 1000 individuals lives in an ecosystem that can support a maximum of 2000 zebrafish. The per capita rate of increase for the population is 0.01 for the year. What is the population growth rate?

4. In a scenario where: ***r*** = 0.25; **K** = 18,000;
    a. What is **G** when i) **N** = 4,500; ii) N = 9,000; and iii) **N** = 13,500?
    b. Which **N** level results in the highest population growth rate and why?

5. A chipmunk population is experiencing exponential growth with a population growth rate of 265 individuals/year, and a per capita rate of increase of 0.15. How many chipmunks are currently in this population?

6. Scientists discovered a new species of frog and were able to estimate its population at 755 individuals. At the end of the year, 105 frogs were added to this population. Assuming the population is undergoing exponential growth, what is the per capita rate of increase?

Test your skills (extra challenge)

7. At the beginning of the year, a wildlife area that is 1,000,000 ha in size has a population of 90 Brown bears with a per capita growth rate of 0.02. It's estimated that brown bears **need** a territory of about 10 km^2 per individual (**note**: 1 km^2 = 100 ha). Use this information to answer the following questions.
    a. What is the density of brown bears in this wildlife preserve currently?
    b. What is the *carrying capacity* of the preserve?
    c. What is the population growth rate for this year?

8. A wildlife ranch currently has a population of polar bears whose death rate is 0.05 and birth rate is 0.12 per year. This particular ranch is isolated from other suitable habitats so there's no immigration into or emigration from this population. This population is experiencing logistic growth and currently has 550 bears. If the population growth rate for the year was 36 bears, what is the carrying capacity of the preserve?

Chapter 3: Human Demography

By the end of this chapter, you will be able to:

- State the current size of the human population.
- Interpret age-structure diagrams.
- Explain what the demographic transition model represents and describe the societal changes that cause the demographic transition.
- Describe what happens to birth rates, death rates, population growth rate, and population size as a country moves through the stages of the demographic transition model.
- Give examples of countries in the different stages of the demographic transition models and match age-structure diagrams with the stages of the demographic transition model.
- Define life expectancy and explain how it changes as a country moves through the demographic transition model.
- Define fertility and explain how it changes as a country moves through the demographic transition model.

Chapter outline

1. The human population
2. Demography
3. Age structure diagrams
4. The demographic transition model
5. Life expectancy
6. Fertility

3.1 The human population.

The human population is growing rapidly. For most of human history, there were fewer than 1 billion people on the planet. During the time of the agricultural revolution, 10,000 B.C., there were only 5-10 million people on Earth - which is basically the population of New York City today. In 1800, when the Industrial Revolution began, there were approximately 1 billion people on Earth (Figure 3.1). We've added 6 billion people to the human population in just a little over 200 years. This demonstrates the capacity of the human population to exhibit exponential growth (Chapter 2).

What is the current human population? Use this World population clock link to determine the current human population: http://math.berkeley.edu/~galen/popclk.html

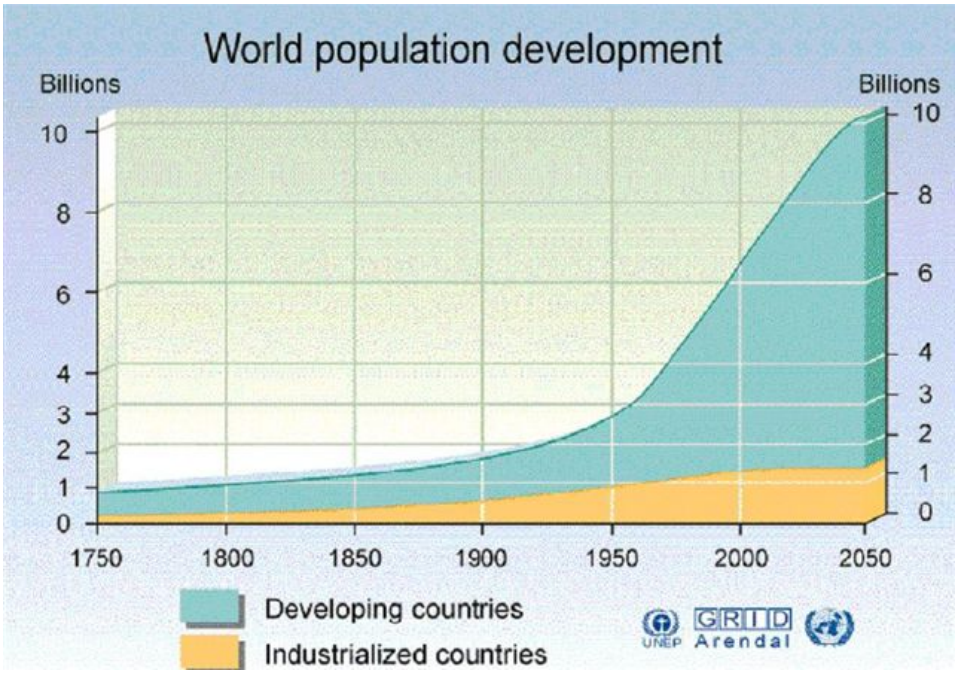


Figure 3.1: Shows the increase in human population size starting in 1750 and predicted out to 2050. The orange area represents the human population in industrialized countries and the blue/green area represents the human population in less-industrialized (developing) countries. The greatest amount of human population growth will be in less-industrialized countries.

3.2 Demography

Demography applies the principles of population ecology (chapter 2) to the human population. Demographers study how human populations grow, shrink, and change in terms of age and gender compositions. Demographers also compare populations in different countries or regions.

3.3 Age structure diagrams

One of the tools that demographers use to understand populations is the **age structure diagram**. This diagram shows the distribution by ages of females and males within a certain population in graphic form. Figure 3.2 shows a diagram for the United States population. In this diagram, the ages are arranged so that age ranges are grouped together, for example: 0 – 4 years, 5 – 9 years, and so on. The population of each group is represented as a bar extending from a central vertical line, with the length of each bar dependent upon the total population for that particular group. The centerline separates the females from the males. The female and male populations for each group are represented by the distance from the centerline, with females on the right and males on the left.

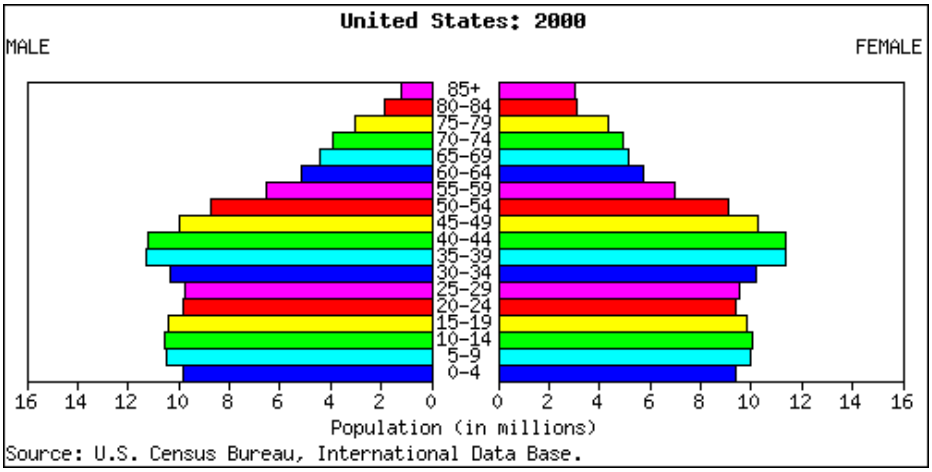


Figure 3.2: Age Structure diagram for the U.S. in 2000

By looking closely at the age structure diagram, one will notice slightly more boys in the younger age groups than girls; however, the ratio tends to reverse in the upper age groups, when females tend to outnumber males. Many countries have a female majority as a result of the longer life expectancy for females.

The following age structure diagrams (Figure 3.3) show the United States in 2005 and 2010. Please note the slightly different x-axes scale on these diagrams compared to the 2000 diagram above (Figure 3.2). You can see the aging group of baby boomers move upward when you compare these 3 age structure diagrams. There are also more elderly (80+) individuals, especially women, in 2005 and 2010.

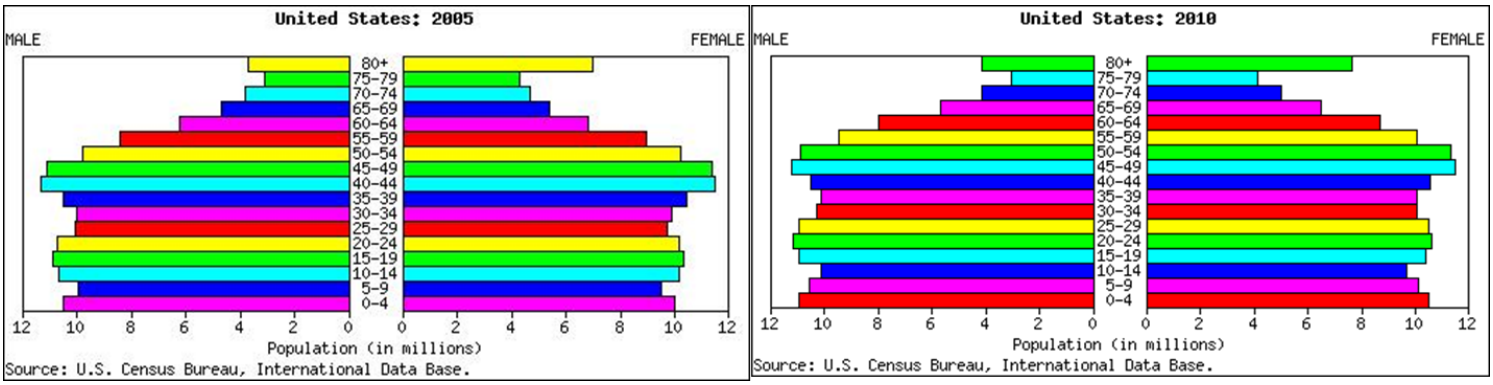


Figure 3.3: Age Structure diagram for the U.S. in 2005 and 2010.

An age-structure diagram provides a snapshot of the current population and can represent information about the past and give potential clues about future problems. When you are interpreting age-structure diagrams, it is important to compare the width of the base to the rest of the population. If the base is very wide compared to the upper parts of the diagram, then this indicates a lot of young people (pre-reproductive) in the population compared to older generations i.e. a high birth rate and a rapidly growing population. If the base is smaller than the upper parts of the diagram, then this indicates few young people in the population compared to older generations (post-reproductive). This population has low birth rates and is shrinking.

3.4 The Demographic Transition Model

The demographic transition model shows the changes in the patterns of birth rates and death rates that typically occur as a country moves through the process of industrialization or development. The demographic transition model was built based on patterns observed in European counties as they were going through industrialization. This model can be applied to other countries, but not all countries or regions fit the model exactly. And the pace or rate at which a country moves through the demographic transition varies among countries.

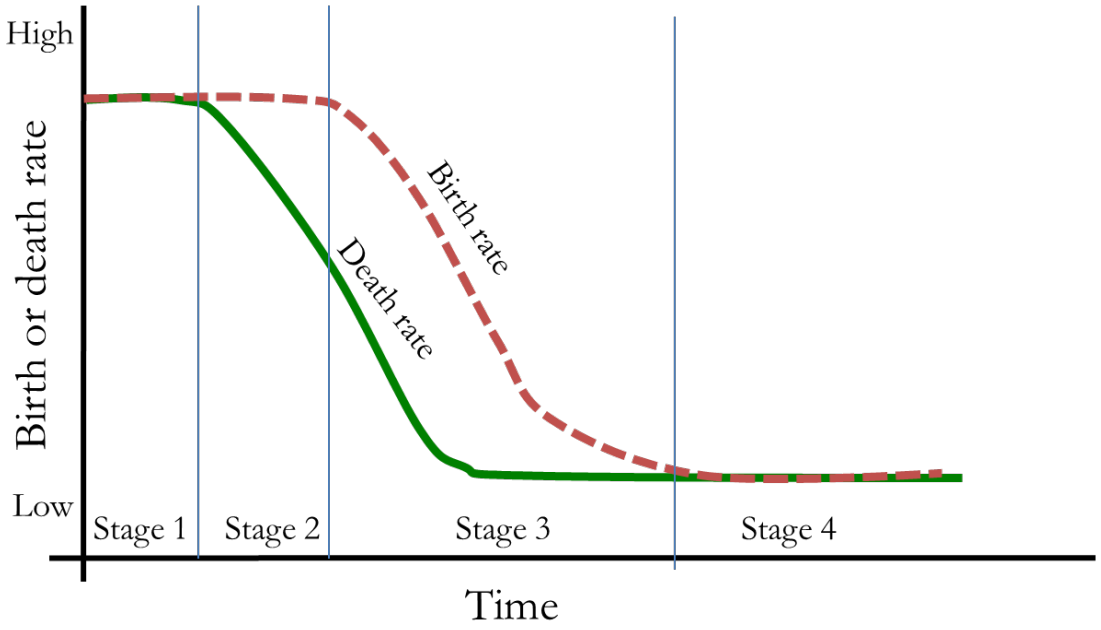


Figure 3.4: The demographic transition model shows how birth rates and death rates change over time as a country becomes more developed. The demographic transition model is typically divided into four stages. The green line represents death rates and the dashed red line represents birth rates.

In the demographic transition model, a country begins in Stage 1, the preindustrial stage. In Stage 1 (Figure 3.4), both birth rates and death rates are high. The high death rates are because of disease and potential food scarcity. A country in Stage 1 of the demographic transition model does not have good health care; there may not be any hospitals or doctors. Children are not vaccinated against common diseases and therefore many children die at a young age. Infant and childhood **mortality rates** (death rates) are very high. A society in Stage 1 is likely based upon agriculture and most people grow their own food. Therefore, droughts or flood can lead to widespread food shortages and death from famine. All of these factors contribute to the high death rate in Stage 1. Partly to compensate for the high death rates, birth rates are also high. High birth rates mean that families are large and each couple, on average, has many children. When death rates are high, having many children means that at least one or two will live to adulthood. In Stage 1, children are an important part of the family workforce and are expected to work growing food and taking care of the family.

As you are examining the stages of the demographic transition model, remember that:

Population Growth Rate = Birth Rate – Death Rate

In Stage 1, birth rates are high, but death rates are high as well. Therefore, population growth rate is low or close to zero (Figure 3.5).

As a country develops, medical advances are made such as access to antibiotics and vaccines. Sanitation improvements, such as proper waste and sewage disposal, and water treatment for clean drinking water also progress. Food production also increases. Together these changes lead to falling death rates which marks the beginning of Stage 2 (Figure 3.4). Death rates continue to fall throughout Stage 2 as conditions improve. This means that people are living longer and childhood morality drops. However, birth rates are still high in Stage 2. There is a time lag between the improving conditions and any subsequent changes in family size, so women are still having many children and now more of these children are living into adulthood. In Stage 2, the birth rate is higher than the death rate, so population growth rate is high. This means that population size increases greatly during Stage 2 of the demographic transition model (Figure 3.5).

A falling birth rate marks the beginning of Stage 3 in the demographic transition model. As a country continues to industrialize, many women join the workforce. Additionally, raising children becomes more expensive and children no longer work on the family farm or make large economic contributions to the family. Individuals may have access to birth control and choose to have fewer children. This leads to a drop in birth rates and smaller family sizes. Death rates also continue to drop during Stage 3 as medicine, sanitation and food security continue to improve. Even though both birth rates and death rates are falling throughout Stage 3, birth rates are higher than death rates. This means that population growth rate is high and that population size continues to increase in Stage 3 of the demographic transition model (Figure 3.5).

Birth rate and death rates drop to low, stable, approximately equal levels in Stage 4. Death rates are low because of medical advances, good sanitation, clean drinking water and food security. Birth rates are low because of access to birth control and many women delay having their first child until they have worked. Childhood mortality is low, life expectancy is high, and family size is approximately two children per couple. With low birth rates and low death rates, population growth rate is approximately zero in Stage 4 (Figure 3.5).

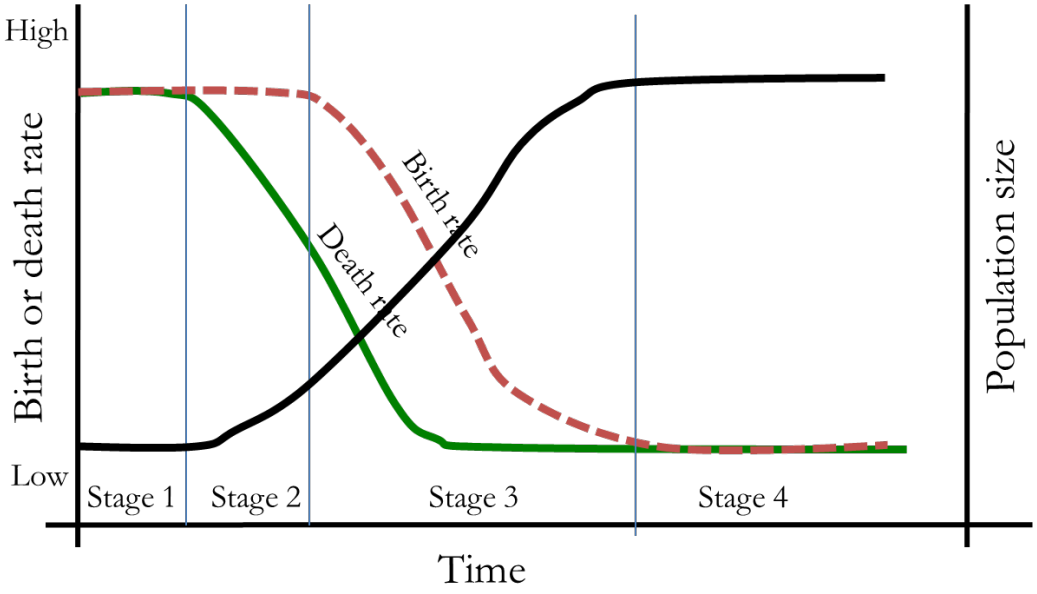


Figure 3.5: This figure repeats the demographic transition model of Figure 3.4, with the changes in population size (y-axes on the far right) shown by the black line. Population size is low and stable in Stage 1, increases

rapidly in Stage 2 and 3 because birth rates are higher than death rates, and then is high and stable again in Stage 4.

3.5 Life expectancy

Life expectancy is the average number of years that a person in a particular population is expected to live. Life expectancy at birth is the number of years a newborn infant would live if mortality rates at the time of its birth did not change. For example, the life expectancy at birth for someone born in 2014 in Japan is 84.46 years while the life expectancy at birth for someone born in the United States in 2014 is 79.56 years (source: https://www.cia.gov). As a country moves through the demographic transition model, life expectancy increases. Overall, life expectancy has increased for most countries and regions over the past 100 years. However, there is still a significant amount of variation in life expectancy in different regions of the world.

Use this World Health Organization interactive map to compare life expectancy among different countries: http://gamapserver.who.int/gho/interactive_charts/mbd/life_expectancy/atlas.html

What other countries have a life expectancy at birth similar to the United States? List two countries that have a higher life expectancy and two countries that have a lower life expectancy than the United States.

3.6 Fertility

Fertility is the actual level of reproduction of a population per individual, based on the number of live births that occur. Total fertility is the average number of children born to each woman, over the woman's lifespan, in a population. Birth rate and fertility are closely linked terms. As a country moves through the demographic transition model, fertility rates decrease. Overall, fertility rates have decreased for most countries and regions over the past 50 years (Figure 3.6). However, there is still a significant amount of variation among different regions of the world.

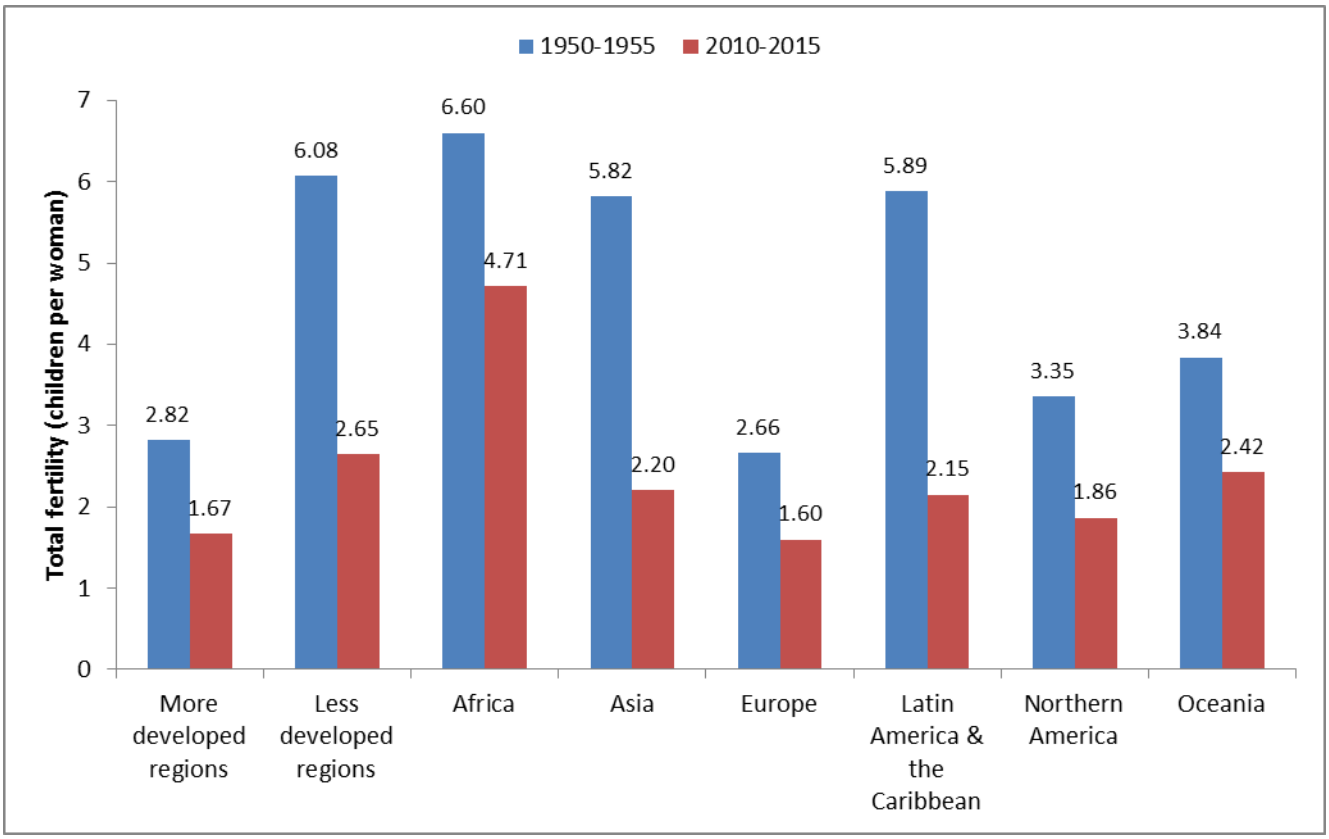


Figure 3.6: Shows the total fertility of different regions of the world. The blue bars are the total fertility estimates from 1950-1955. The red bars are the total fertility estimates from 2010-2015. More developed regions include Europe, Northern America (US and Canada), Australia, New Zealand and Japan. Less developed regions comprise all regions of Africa, Asia (except Japan), Latin America and the Caribbean plus Melanesia, Micronesia and Polynesia. Oceania includes Australia, New Zealand, Melanesia, Micronesia and Polynesia. Data are from the United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects, 2015 Revision. UN http://esa.un.org/unpd/wpp/DVD/

Additional recourses

United Nations Development Programme, Human Development Reports
http://hdr.undp.org/en/content/demography-and-human-development

Carrying capacity of ecosystems and human demography

http://institutmichelserres.ens-lyon.fr/spip.php?article38

Terms list

Age structure diagram

Demography

Demographic transition model

Fertility

Life expectancy

Mortality rate

Population growth rate

Pre-reproductive/post-reproductive age

CHAPTER 4: NON-RENEWABLE ENERGY



Watts Bar Nuclear Power Plant in East Tennessee. Image from Tennessee Valley Authority (Public Domain).

Chapter outline

4.1 What is Energy?
4.2 Fossil Fuels
4.3 Coal
4.4 Oil
4.5 Natural gas
4.6 Fossil fuels and greenhouse gases
4.7 Nuclear energy

Learning Objectives

By the end of this chapter, students will be able to

- List specific examples of non-renewable energy sources
- Explain what makes an energy source non-renewable
- Describe the main types of fossil fuels and how they formed
- Explain the environmental impacts associated with exploration, extraction and use of the different types of fossil fuels
- Explain nuclear energy, how it works, its benefits and risks

4.1 What is Energy?

Energy is the ability of a system to do work. A system has done work if it has exerted a force on another system over some distance. When this happens, energy is transferred from one system to another. At least some of the energy is also transformed from one type to another during this process. One can keep track of how much energy transfers into or out of a system. There are two categories that all energy falls into: kinetic and potential. **Kinetic energy** refers to types of energy associated with motion (Figure 4.1, top). For example, a rock rolling down a hill, the wind blowing through trees, water flowing over a dam, and a cyclist riding a bicycle are just a few examples of kinetic energy. **Potential energy** is energy possessed by an object or system due to its position in space relative to another object or system and forces between the two (Figure 4.1, bottom). Examples include a rock poised at the top of a hill and water stored behind a dam. Some forms of energy are part kinetic and part potential energy. **Chemical energy** describes the *potential* of a chemical substance to undergo a chemical reaction and transform other chemical substances; hence it is a form of potential energy. Examples include energy stored in the food you eat and the gasoline that you put in your car.



Examples of different forms of **kinetic** energy



Examples of different forms of **potential** energy

Figure 4.1: Examples kinetic (top) and potential (bottom) forms of energy. *All images were obtained from Wikimedia commons (public domain).*

Living organisms need energy to perform life-sustaining "work" in order to survive. For nearly all living systems on Earth, the sun is the ultimate source of that energy. Over time, we humans have developed an understanding of energy that has allowed us to harness it for uses well beyond basic survival. The development and evolution of human society is largely attributed to our relationship with energy. The first major advancement in human understanding

of energy was the mastery of fire for cooking and heating. Modern civilization is especially dependent on energy and some of its most distinct characteristics such as population growth, environmental impact and climate change are all a consequence of energy use. We use energy to heat and light our homes; power our machinery; fuel our vehicles; produce plastics, pharmaceuticals, and synthetic fibers; and provide the comforts and conveniences to which we have grown accustomed in the industrial age. Societal complexity, affluence, and the gap between poor and rich peoples are all related to our level of energy consumption.

4.2 Fossil Fuels

Fossil fuels is the term given to energy sources with a high **hydrocarbon** content (see Chapter 1 for a review of hydrocarbon molecules) found in the Earth's crust that formed in the geologic past and can be burned to release their energy. They were formed from prehistoric plants and animals that lived hundreds of millions of years ago (100 – 500 million years ago). When these ancient living organisms died they were quickly buried and subjected to immense pressure from overlying earth materials including layers of mud, rock, sand, and sometimes surface water bodies such as oceans and lakes.

During the millions of years that passed, the dead plants and animals slowly decomposed in **anaerobic** (very low to no oxygen) conditions and their chemical energy became concentrated. The organic compounds that once made up tissues of these organisms were chemically changed under high pressures and temperatures. While some fossil fuels may be in the process of formation today, the amount of time required for usable quantities to form is measured in millions of years, so these fuels will never be available for us. Thus for all practical purposes we consider fossil fuels to be finite and **non-renewable.**

4.2.1 Fossil Fuel Types and Formation

There are three main types of fossil fuels – natural gas, oil, and coal – and the specific type formed depends on the combination of organic matter that was present, how long it was buried and what temperature and pressure conditions existed when they were decomposing. **Oil** and **natural gas** were created from organisms that lived in water and were buried under ocean or river sediments. Long after the great prehistoric seas and rivers vanished, heat, pressure, and bacteria combined to compress and transform the organic material under layers of silt or shale rock (Figure 4.2). In most areas, a thick liquid called oil formed first, but in deeper, hot regions underground, the transformation process continued until natural gas was formed. Over time, some of this oil and natural gas began working its way upward through the earth's crust until they ran into rock formations called "**caprocks**" that are dense enough to prevent them from seeping to the surface. It is from under these caprocks that most oil and natural gas is retrieved today.

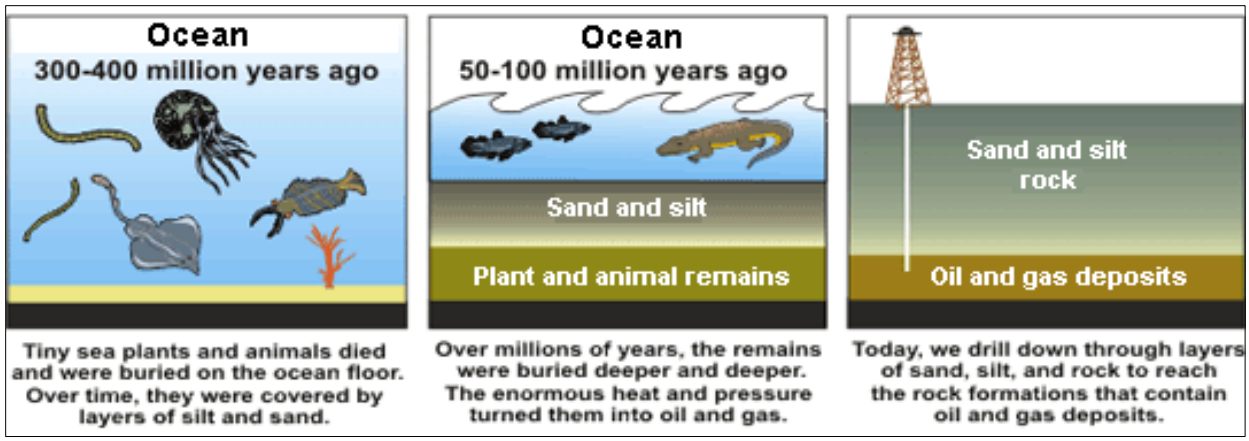


Figure 4.2: Oil and natural gas (petroleum) formation. *Source*: U.S. Energy Information Administration. http://www.eia.gov/energyexplained/index.cfm?page=natural_gas_home

Coal is a fossil fuel that formed from the remains of trees, ferns, and other plants that lived 300 to 400 million years ago (Figure 4.3). In some areas, such as portions of what is now the eastern United States, coal was formed from swamps covered by sea water. The sea water contained a large amount of sulfur, and as the seas dried up, the sulfur was left behind in the coal. Scientists are working on ways to take the sulfur out of coal because when coal burns, the sulfur is released in to the atmosphere as an air pollutant (see Chapter 6). Some coal deposits, however, were formed from freshwater swamps which had very little sulfur in them. These coal deposits, located largely in the western part of the United States, have much less sulfur in them.

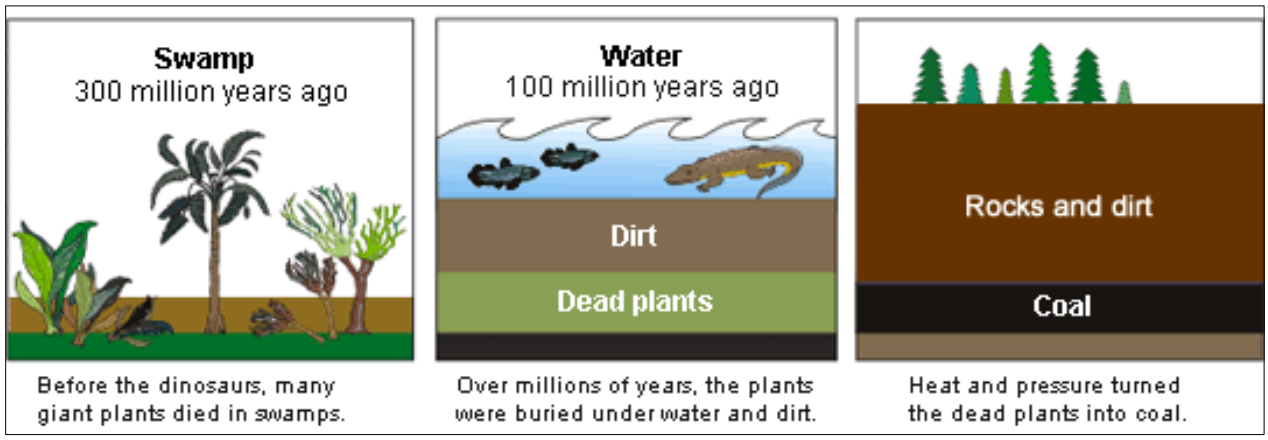


Figure 4.3: The process of coal formation. ***Source:*** U.S. Energy Information Administration.

4.2.2 Consumption

Historically, human prosperity has been directly correlated with energy use. The health and vitality of world societies critically depends on energy, most of which comes from fossil fuels (Figure 4.4). Energy resources, however, are unevenly distributed throughout the world, and so are the consumption rates. Developed regions generally consume far more energy than the developing regions. For example, the United States has only about 5% of the world's population but constitutes over 20% of the world's energy consumption. Additionally,

developing countries devote a larger proportion of energy consumption to subsistence activities such as growing and preparing food, and heating homes. Industrialized nations rely more on mechanized equipment and technology and, therefore, a greater proportion of their energy consumption goes to transportation and industry.

Fossil fuels can be utilized without being converted or transformed to another form of energy, this is referred to as **primary energy** consumption. In their primary form, fossil fuels can be used for transportation, heating and cooking, or used to generate electricity. The use of **electricity** is a form of **secondary energy** consumption. Transforming fossil fuel energy into electricity allows for easier transportation over long distances and application to a variety of uses. Additionally, there are four major sectors that consume energy: 1) The *industrial sector* which includes facilities and equipment used for manufacturing, agriculture, mining, and construction; 2) The *transportation sector* includes vehicles that transport people or goods including cars, trucks, buses, motorcycles, trains, aircraft, boats, barges, and ships; 3) The *residential sector* consists of homes and apartments; 4) The *commercial sector* includes offices, malls, stores, schools, hospitals, hotels, warehouses, restaurants, places of worship, and more. Each of these sectors also consumes electricity produced by the electric power sector.

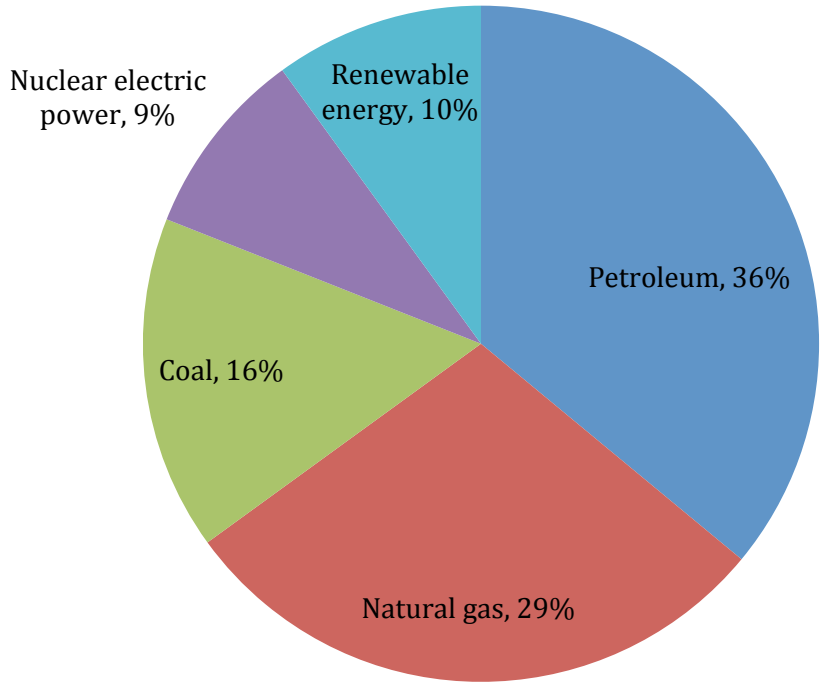
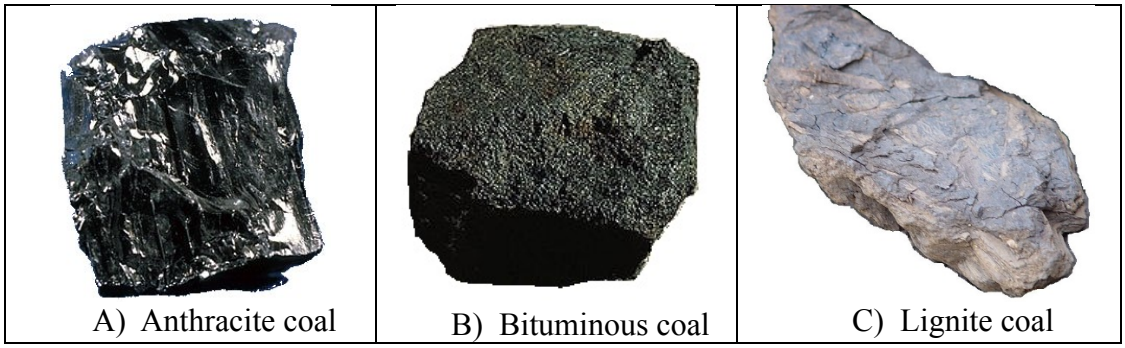


Figure 4.4: U.S. primary energy consumption by source (all sectors), 2015, showing that about 80 % of our energy consumption comes from fossil fuels. Data from U.S. Energy Information Administration, April 2016.

4.3 Coal

Coal is a combustible black or brownish-black sedimentary rock with a high amount of carbon and hydrocarbons. Coal is classified into four main types, or ranks depending on the types and amounts of carbon present and on the amount of heat energy the coal can produce, including anthracite, bituminous, subbituminous, and lignite (highest to lowest ranked, pictured in Figure 4.5). For us to use the potential energy stored in coal, it first must be mined from the ground. This process in itself uses a great deal of resources and has its own environmental impacts. Coal then typically undergoes processing to make it suitable for use in **coal-fire power plants**. Finally, the processed coal is burned in these power plants, and the kinetic energy released from its combustion is harnessed for electricity generation or other purposes. We will investigate each of these steps individually below.



A) Anthracite coal B) Bituminous coal C) Lignite coal

Figure 4.5: Different types of coal. Images obtained from Wikimedia Commons.

4.3.1 Coal Mining and Processing, and Electricity Generation

There are two primary methods of coal mining: **strip mining** and **underground mining**. Strip-, or surface-, mining uses large machines to remove the soil and layers of rock known as **overburden** to expose coal seams. It is typically used when the coal is less than 200 feet underground. **Mountaintop removal** is a form of surface mining where the tops of mountains are blasted with dynamite and removed to access coal seams. After the mining is finished, the disturbed area can be re-covered with topsoil, and the area is replanted. However, the topography of the mountain is permanently altered.

Underground mining, sometimes called deep mining, is used when the coal is several hundred feet below the surface. Some underground mines are thousands of feet deep, and extend for miles. Miners ride elevators down deep mine shafts and travel on small trains in long tunnels to get to the coal. The miners use large machines that dig out the coal.

Once mined, coal may go to a preparation plant located near the mining site where it is cleaned and processed to remove impurities such as rocks and dirt, ash, sulfur, and other unwanted materials. This process increases the amount of energy that can be obtained from a unit of coal, known as its **heating value**.

Finally, the mined and processed coal must be transported. Transportation can be more expensive than mining the coal. Nearly 70% of coal delivered in the United States is transported, for at least part of its trip, by train. Coal can also be transported by barge, ship, or truck. Coal can also be crushed, mixed with water, and sent through a slurry **pipeline**. Sometimes, coal-fired electric power plants are built near coal mines to lower transportation costs.

Once at the power plant, coal is first pulverized into a fine powder then mixed with hot air and blown into a **furnace**, allowing for the most complete combustion and maximum heat possible. Purified water, pumped through pipes inside a **boiler**, is turned into steam by the heat from the combustion of coal. The high pressure of the steam pushing against a series of giant **turbine** blades turns the turbine shaft. The turbine shaft is connected to the shaft of the **generator**, where magnets spin within wire coils to produce electricity. After doing its work in the turbine, the steam is drawn into a **condenser**, a large chamber in the basement of the power plant. In this important step, millions of gallons of cool water from a nearby source (such as a river or lake) are pumped through a network of tubes running through the condenser. The cool water in the tubes converts the steam back into water that can be used over and over again in the plant. The cooling water is returned to its source without any contamination except at a higher temperature than when first extracted from the river or lake. Figure 4.6 below is a schematic diagram showing a typical layout of a coal-fire power plant. You can also watch a short video of a virtual tour of a coal power plant at the URL provided below.

Coal Power Plant Virtual Tour Video

https://www.youtube.com/watch?v=2IKECt4Y3RI

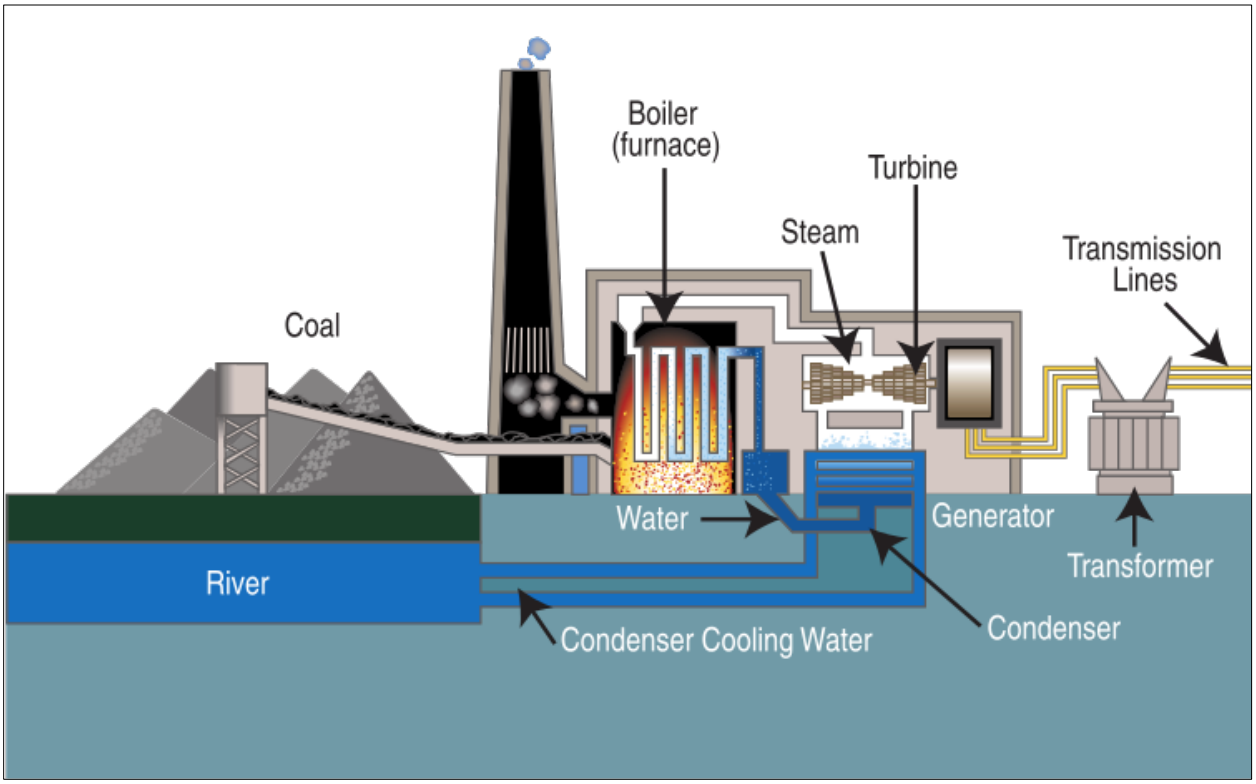


Figure 4.6: Diagram of a typical steam-cycle coal power plant (proceeding from left to right). Image by US Tennessee Valley Authority – Public domain. www.tva.com

4.3.2 Impacts of coal mining and burning

Impacts of coal mining on the environment

A majority of the coal mined in the United States (about 66%) is from surface, or strip mines which leave highly visible impacts at the surface. Strip mining operations generally involve removing soils, rock, and other material to access shallow deposits of coal and therefore leave permanent scars on the landscape. It also involves the destruction of substantial amounts of forests and other ecosystems, destroying natural habitats and threatening biodiversity.

Mountaintop removal, the extreme form of strip mining, has affected large areas of the Appalachian Mountains in West Virginia and Kentucky. The tops of mountains are removed using a combination of explosives and mining equipment and the material is deposited into nearby valleys. This technique not only alters the landscape (Figure 4.7) but affects the health and quality of nearby streams by depositing rocks, dirt, and pollutants that can harm aquatic wildlife. While mountaintop removal mining has existed since the 1970s, its use became more widespread and controversial beginning in the 1990s. U.S. laws require that dust and water runoff from areas affected by coal mining operations be controlled, and that the area be **reclaimed**, and returned to close to its original condition.



Figure 4.7: A) Strip mine for lignite coal at Garzweiler near Koln, Germany. Image from Wikimedia commons https://commons.wikimedia.org/wiki/File:Garzweiler.strip.mine.jpg B) Mountaintop removal in Eunice WV, photo by Roston, obtained from https://commons.wikimedia.org/wiki/File:Euniceblast3.JPG

One of the largest environmental impacts of underground mining may be the **methane** gas that must be vented out of mines to make the mines a safe place to work. Methane is a **greenhouse gas**, meaning that it enhances the greenhouse effect naturally occurring in our atmosphere, and contributes to global warming and global climate change. Its global warming potential, or relative capacity to produce the greenhouse effect, is higher than that of carbon dioxide (see chapter 7). Other impacts of underground mining include ground collapse above

mine tunnels and draining of acidic water from abandoned mines into nearby streams. Acidic water lowers the pH (resulting in increased **acidity**), which is detrimental to aquatic organisms. This **acid mine drainage** is an environmental impact associated with both underground mining and strip mining.

Impacts of coal burning on the environment and human health

In the United States and most of the world, most of the coal consumed is used as a fuel to generate electricity. Burning coal produces emissions such as **sulfur dioxide** (SO_2) and **nitrogen oxides** (NO_x) that are associated with acid rain (more on this in chapter 6). **Carbon dioxide** (CO_2), another emission resulting from burning coal, is a major greenhouse gas that is associated with global warming (see chapter 7).

Ash (including fly ash and bottom ash) is a residue created when coal is burned at power plants. In the past, fly ash was released into the air through the smokestack, where it would contribute to **particulate matter** air pollution (see chapter 6). Laws now require that much of the fly ash now must be be captured by pollution control devices, like scrubbers. In the United States, fly ash is generally stored at coal power plants or placed in landfills. Pollution leaching from ash storage and landfills into groundwater and the rupture of several large impoundments of ash are environmental concerns.

Burning coal produces emissions that also impact human health. Emissions such as sulfur dioxide (SO_2), nitrogen oxides (NO_x) and particulates contribute to respiratory illnesses. Particulates also contribute to a condition among coal miners and other coal workers known as coal workers' pneumoconiosis (CWP) or black lung disease, which results from long exposure to coal dust. Inhaled coal dust progressively builds up in the lungs and is unable to be removed by the body; this leads to inflammation, fibrosis, and in worse cases, tissue death (necrosis).

Coal is the largest source of **mercury** and also a source of other **heavy metals**, many of which have been linked to both neurological and developmental problems in humans and other animals. Mercury concentrations in the air usually are low and of little direct concern. However, when mercury enters water, either directly or through deposition from the air, biological processes transform it into **methylmercury**, a highly toxic chemical that accumulates in fish and the animals (including humans) that eat fish.

4.3.3 Reducing the environmental impacts of coal use

Regulations such as the **Clean Air Act** and the **Clean Water Act** require industries to reduce pollutants released into the air and water. Below are some actions that have been taken to reduce the negative impacts of coal on human and environmental health:

- **Clean coal technology**: Industry has found several ways to reduce sulfur, NO_x, and other impurities from coal before burning.
- Coal consumers have shifted toward greater use of low sulfur coal.
- Power plants use **scrubbers**, to clean SO_2, NO_x, particulate matter, and mercury from the smoke before it leaves their smokestacks. In addition, industry and the U.S. government have cooperated to develop technologies that make coal more energy-efficient so less needs to be burned.
- Research is underway to address emissions of carbon dioxide from coal combustion. **Carbon capture & sequestration** separates CO_2 from emissions sources and recovers it in a

concentrated stream. The CO_2 can then be sequestered, which puts CO_2 into storage, possibly underground, where it will remain permanently (see chapter 7).

- Reuse and recycling can also reduce coal's environmental impact. Land that was previously used for coal mining can be reclaimed and used for airports, landfills, and golf courses. Waste products captured by scrubbers can be used to produce products like cement and synthetic gypsum for wallboard.

4.4 Oil

Petroleum Oil is currently the most widely used fossil fuel and accounts for about one third of global energy consumption. Unlike coal, which is primarily used as a fuel for electricity generation, oil is primarily used as a fuel for **transportation**. Oil is also used to manufacture **plastics** and other synthetic compounds ubiquitous to our everyday life. **Crude** (unprocessed) oil varies greatly in appearance depending on its composition. It is usually black or dark brown (although it may be yellowish, reddish, or even greenish). In the reservoir it is usually found in association with natural gas, which being lighter forms a gas cap over the oil.

Oil is made up of hydrocarbons which are molecules that contain hydrogen and carbon in various lengths and structures, from straight chains to branching chains to rings. Hydrocarbons contain a lot of energy and many of the things derived from crude oil like gasoline, diesel fuel, paraffin wax and so on take advantage of this energy.

4.4.1 Extraction

Oil is mainly obtained by drilling either on land (**onshore**) or in the ocean (**offshore**). Early offshore drilling was generally limited to areas where the water was less than 300 feet deep. Oil and natural gas drilling rigs now operate in water as deep as two miles. Floating platforms are used for drilling in deeper waters. These self-propelled vessels are attached to the ocean floor using large cables and anchors. Wells are drilled from these platforms which are also used to lower production equipment to the ocean floor. Some drilling platforms stand on stilt-like legs that are embedded in the ocean floor. These platforms hold all required drilling equipment as well as housing and storage areas for the work crews.

Offshore oil producers are required to take precautions to prevent pollution, spills, and significant changes to the ocean environment. Offshore rigs are designed to withstand hurricanes. Offshore production is much more expensive than land-based production. When offshore oil wells are no longer productive enough to be economical, they are sealed and abandoned according to applicable regulations.

4.4.2 Processing and Refining

When extracted, crude oil consists of many types of hydrocarbons as well as some unwanted substances such as sulfur, nitrogen, oxygen, dissolved metals, and water all mixed together. Unprocessed crude oil is therefore, not generally useful in industrial applications and must first be separated into different useable products at a **refinery** (Figure 4.8). All refineries perform three basic steps: separation, conversion, and treatment in the processing and refining of crude oil.



Figure 4.8: Tesoro Corporation Oil Refinery in Anacortes, Washington. Photo by Walter Siegmund. https://commons.wikimedia.org/wiki/Oil_refinery#/media/File:Anacortes_Refinery_31904.JPG

During **separation**, the various products (hydrocarbons) are separated in to different components (called *fractions*), by taking advantage of the differences in boiling temperature of the components. This process is called *fractional distillation* and involves heating up the crude, letting it vaporize and then condensing the vapor. The lightest components have the lowest boiling temperature and rise to the top while the heaviest which also have the highest boiling temperature remain at the bottom.

Conversion is the chemical processing in which some of the fractions are transformed in to other products, for example, a refinery can turn diesel fuel into gasoline depending on the demand for gasoline. Conversion can involve breaking larger hydrocarbon chains into smaller ones (cracking), combining smaller chains into larger ones (unification) or rearranging the molecules to created desired products (alteration).

Treatment is done to the fractions to remove impurities such as sulfur, nitrogen and water among others. Refineries also combine the various fractions (processed and unprocessed) into mixtures to make desired products. For example, different mixtures of hydrocarbon chains can create gasolines with different octane ratings, with and without additives, lubricating oils of various weights and grades (e.g., WD-40, 10W-40, 5W-30, etc.), heating oil and many others. The products are stored on-site until they can be delivered to various markets such as gas stations, airports and chemical plants.

A 42 U.S. gallon barrel of crude oil yields about 45 gallons of petroleum products because of refinery processing gain. This increase in volume is similar to what happens to popcorn when it is popped. Gasoline makes up the largest fraction of all petroleum products obtained (Figure 4.9). Other products include diesel fuel and heating oil, jet fuel, petrochemical feedstocks, waxes, lubricating oils, and asphalt.

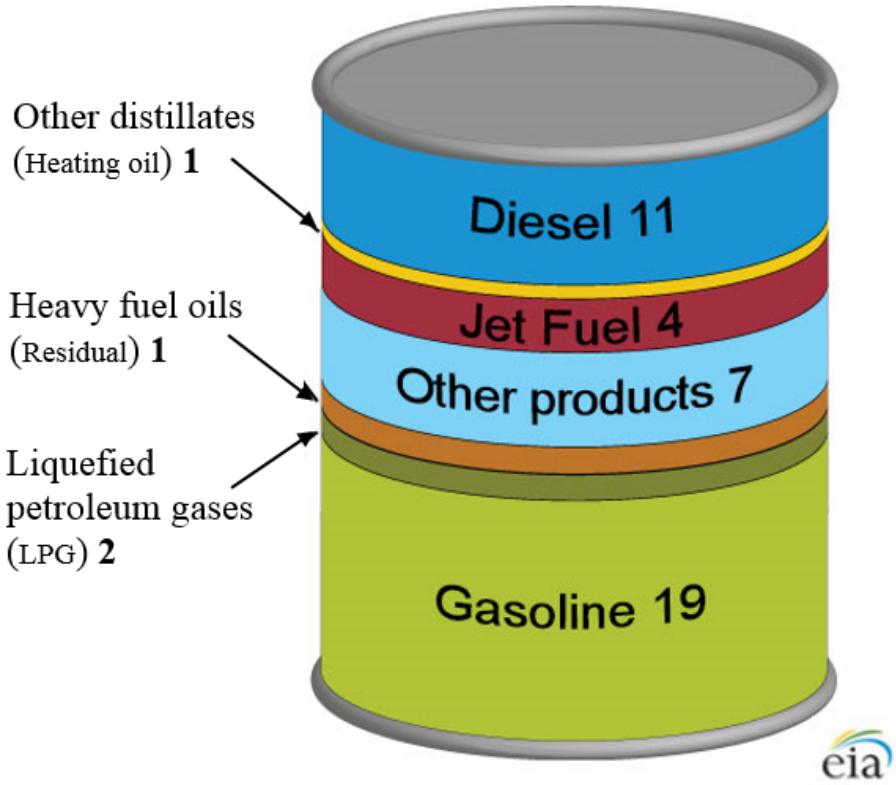


Figure 4.9:Main products (measured in gallons) made from a barrel of crude oil, 2013. ***Source***: U.S. Energy information administration http://www.eia.gov/energyexplained/index.cfm?page=oil_home

4.4.3 Fracking for oil

Hydraulic fracturing, informally referred to as "fracking," is an oil well development process that typically involves injecting water, sand, and chemicals under high pressure into a bedrock formation via the well. This process is intended to create new fractures in the rock as well as increase the size, extent, and connectivity of existing fractures. Hydraulic fracturing is a well-stimulation technique used commonly in low-permeability rocks like tight sandstone, shale, and some coal beds to increase oil flow to a well from petroleum-bearing rock formations (Figure 4.10).

Energy development often requires substantial amounts of water, and hydraulic fracturing is no exception. Water is needed not only for the traditional drilling process, but also for the actual fracturing as well. Water is first mixed with chemicals and fine sands, then pumped at extremely high pressure into the shale rock to fracture it, forming pathways for the oil and gas to reach the well. The water is then recovered, along with the oil and gas.

There are concerns regarding the potential contamination of fresh groundwater resources from oil and gas extraction wells that use hydraulic fracturing; either from the petroleum resource being produced or from the chemicals introduced in the fracturing process. Fracking fluid flowback – the fluid pumped out of the well and separated from oil and gas – not only contains the chemical additives used in the drilling process but also contains heavy metals, radioactive materials, **volatile organic compounds** (VOCs) and hazardous air pollutants such as

benzene, toluene, ethylbenzene and xylene. In some cases, this contaminated water is sent to water treatment plants that are not equipped to deal with some of these classes of contamination.

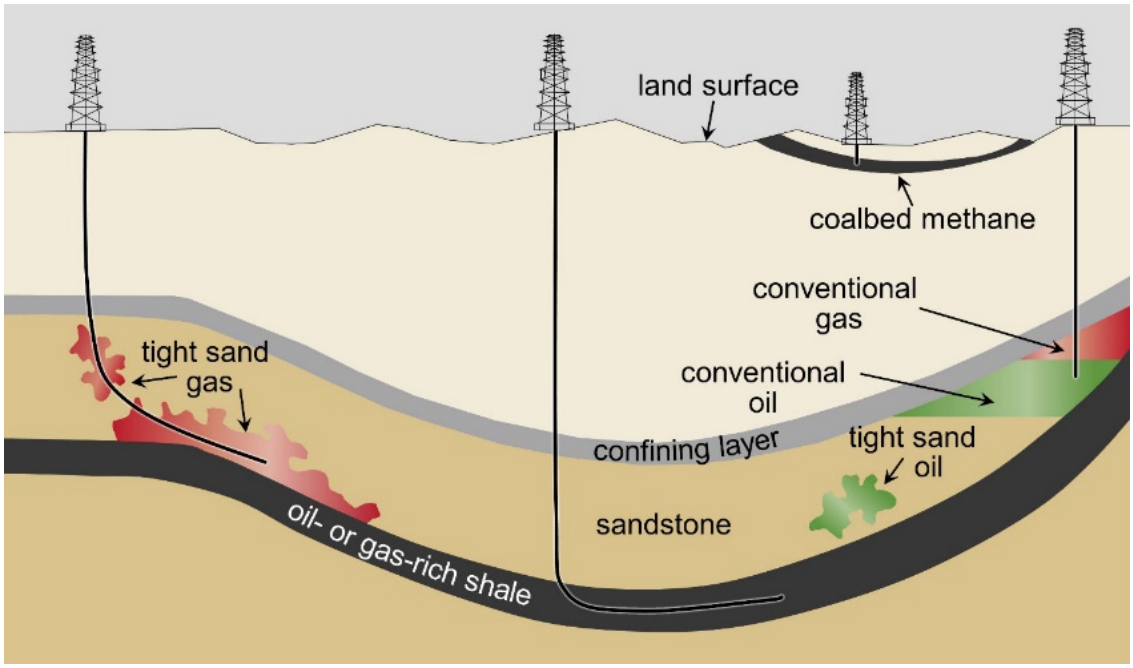


Figure 4.10: Schematic cross-section of general types of oil and gas resources and the orientations of production wells used in hydraulic fracturing. Source: US EPA (Public Domain)

4.4.4 Environmental Impacts of Oil

Burning petroleum oil products releases emission such as **carbon monoxide** (CO), sulfur dioxide (SO_2), nitrogen oxides (NO_x), and particulate material all of which are air pollutants that impact the environment as well as human health (see more on air pollution in Chapter 6). Petroleum also emits carbon dioxide which is a greenhouse gas.

Exploring and drilling for oil may disturb land and ocean habitats. On land, extensive infrastructure such as road networks, transport pipelines and housing for workers are needed to support a full-scale drilling operation. These can pollute soil and water, fragment habitats, and disturb wildlife.

Human-caused **oil spills** in rivers and oceans harm ecosystems. Natural oil seepages do occur and may be a significant source of oil that enters the environment globally, but they are slow, small, and spread out over large areas, and the ecosystem has adapted to them. Spills from tankers or well spills have more catastrophic impacts. The quantity of oil spilled during accidents has ranged from a few hundred tons to several hundred thousand tons but even small spills have been shown to have a great impact on ecosystems.

Oil spills at sea are generally much more damaging than those on land, since they can spread for hundreds of nautical miles in a thin oil slick which can cover beaches with a thin coating of oil. This can kill sea birds, mammals, shellfish and other organisms it coats. Oil spills on land are more readily containable if a makeshift earth dam can be rapidly bulldozed around the spill site before most of the oil escapes, and land animals can avoid the oil more easily. The

amount of oil spilled from ships dropped significantly during the 1990s partly because new ships were required to have a double-hull lining to protect against spills.

Leaks also happen when we use petroleum products on land. For example, gasoline sometimes drips onto the ground when people are filling their gas tanks, when motor oil gets thrown away after an oil change, or when fuel escapes from a leaky storage tank. When it rains, the spilled products get washed into the gutter and eventually flow to rivers and into the ocean. Another way that oil sometimes gets into water is when fuel is leaked from motorboats and jet skis.

When a leak in a storage tank or pipeline occurs, petroleum products can also get into the ground, and the ground must be cleaned up. To prevent leaks from underground storage tanks, all buried tanks are supposed to be replaced by tanks with a double lining.

4.5 Natural Gas

Crude oil is frequently found in reservoirs along with natural gas. In the past, natural gas was either burned or allowed to escape into the atmosphere. Now, technology has been developed to capture the natural gas and either reinject it into the well or compress it into **liquid natural gas** (LNG).

Natural gas is predominately composed of methane (CH_4). Some of the gases that are produced along with methane, such as butane and propane (by-products), are separated and cleaned at a gas processing plant. The by-products, once removed, are used in a number of ways. For example, propane can be used for cooking on gas grills. Natural gas withdrawn from a well may contain liquid hydrocarbons and nonhydrocarbon gases. This is called "wet" natural gas. The natural gas is separated from these components near the site of the well or at a processing plant. The gas is then considered "dry" and is sent through pipelines to a local distribution company, and, ultimately, to the consumer.

Most of the natural gas consumed in the United States is produced in the United States. Some is imported from Canada and shipped to the United States in pipelines. A small amount of natural gas is shipped to the United States as LNG. We can also use machines called **digesters** that turn today's organic material (plants, animal wastes, etc.) into natural gas through the process of anaerobic decomposition. This process replaces waiting for millions of years for the gas to form naturally. The natural gas produced by these digesters is not a fossil fuel, but is rather a renewable source of bioenergy (see chapter 5).

4.5.2 Fracking for Gas

Conventional natural gas is found in permeable reservoirs, typically composed of sandstone or limestone, where extraction is relatively straightforward because the gas generally flows freely. Unconventional gas is found in rocks with extremely low permeability, which makes extracting it much more difficult. Such gas is extracted by employing so called “unconventional” techniques such as hydraulic fracturing (fracking), which has been in use since the late 1940s. In recent decades, fracking technology has greatly improved, and its use has been expanded. The process of fracking for gas is very similar to that of fracking for oil, and the environmental impacts are similar also.

4.6 Fossil Fuels and Greenhouse Gases

Fossil fuels are made up mainly of hydrogen and carbon. When burned, the carbon combines with oxygen to create carbon dioxide (CO_2). The amount of CO_2 produced depends on the carbon content of the fuel. For example, for the same amount of energy produced, natural gas produces about half and petroleum produces about three-fourths of the amount of CO_2 produced by coal. Energy-related CO_2 emissions, resulting from the combustion of coal, petroleum, and natural gas, account for about 80% of total U.S. human-caused (anthropogenic) greenhouse gas (GHG) emissions. There are many sources of non-energy CO_2 emissions, but those emissions account for a relatively small share of total GHG emissions. See chapter 7 for a discussion of the results of GHG emissions.

Energy use is largely driven by economic growth and by weather patterns that affect heating and cooling needs. The fuels used in electricity generation also have an impact on the amount of GHG emissions. In the United States, most of the electricity generated comes from coal power plants and consequently, majority of the carbon dioxide emission resulting from electricity generation is from coal combustion (Figure 4.11). Although the industrial sector is the largest consumer of energy (including direct fuel use and purchased electricity), the transportation sector emits more carbon dioxide because of its near complete dependence on petroleum fuels. The residential and commercial sectors have lower emission levels (most of which comes from fossil energy combustion to produce electricity) than the transportation and industry sectors.

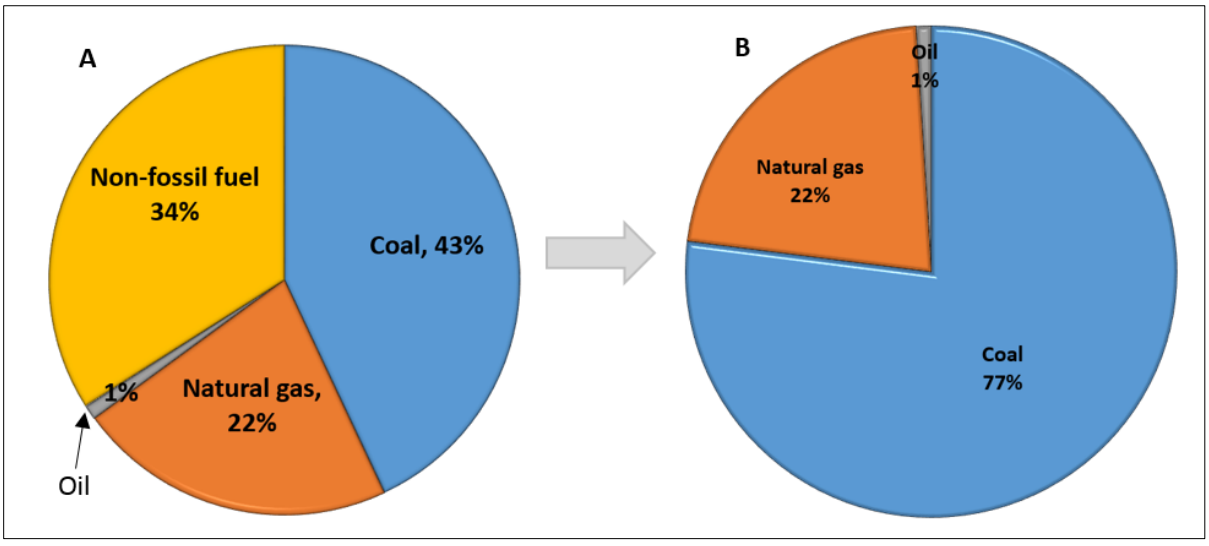


Figure 4.11: A) Major fuel/energy sources for U.S. electricity generation, 2013. B) Resulting carbon dioxide emissions from electricity generation by fuel type, 2013. Based on data from U.S. Energy Information Administration

4.7 Nuclear Energy

Nuclear energy is energy in the **nucleus** (core) of an atom (see chapter 1 for a review of atomic structure). There is enormous energy in the forces that hold protons and neutrons in the

nucleus together. Energy is released when those forces are broken. Nuclear energy can be released from atoms by splitting apart the nucleus of an atom to form smaller atoms, a process known as **nuclear fission**. During nuclear fission, a small atomic particle called a **neutron** hits the uranium atom and splits it, releasing a great amount of energy in the form of heat and **radiation**. More neutrons are also released when the uranium atom splits. These neutrons go on to bombard other uranium atoms, and the process repeats itself over and over again. This is called a **chain reaction** (Figure 4.12). Nuclear power plants use the energy from nuclear fission to produce electricity.

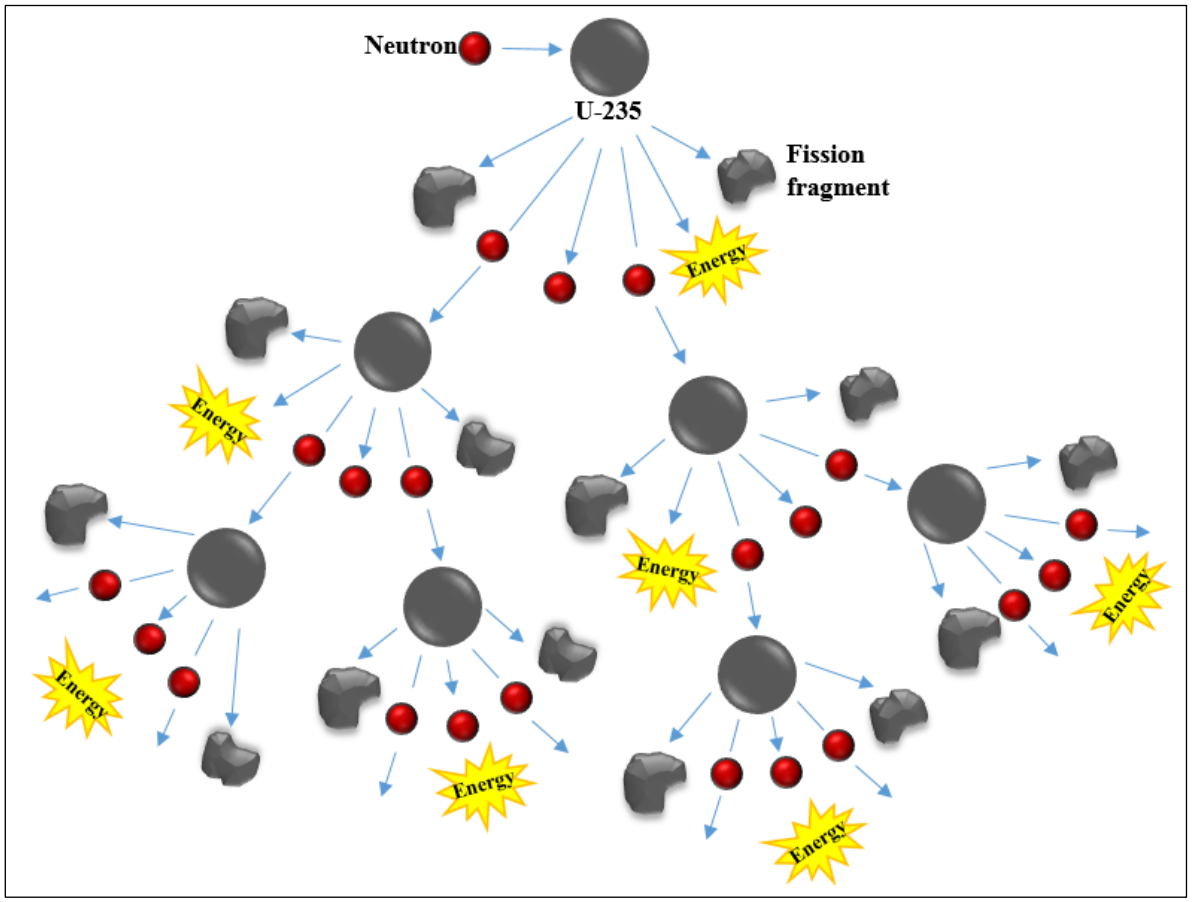


Figure 4.12: Fission chain reaction – begins when a neutron bombards a U-235 atom, splitting it into two fission fragments, along with more neutrons and energy. The neutrons bombard other uranium atoms releasing more energy and more neutrons and the reaction continues.

4.7.1 Nuclear fuel processing

Uranium is a naturally occurring radioactive element that decays into daughter **isotopes** (see chapter 1 for a review of isotopes), releasing radiation energy in the process. There are three naturally occurring isotopes of uranium almost all (99.27 %) of which is uranium-238 (U-238); the remainder consists of U-235 (0.72 %) and U-234 (0.006 %). **U-235** is the preferred nuclear fuel because when its atoms are split (fissioned), they not only emit heat and high energy radiation but also enough neutrons to maintain a chain reaction and provide energy to power a

nuclear power plant. Uranium is found in rocks all over the world but is relatively rare and the supply is finite making it a nonrenewable energy source.

Uranium usually occurs in combination with small amounts of other elements and once it is mined, the U-235 must be extracted and processed before it can be used as a fuel in a nuclear power plant to generate electricity. The process begins with **exploration** for uranium and the development of mines to extract the discovered **ore** (*ore* refers to rock that contains minerals of economic importance). Mining is either conventional (underground or open pit) or unconventional, such as in-place solution mining or heap leaching, which use liquid solvents to dissolve and extract the ore. Mined uranium ore (Figure 4.13 A) typically yields one to four pounds of uranium concentrate per ton of uranium ore (0.05% to 0.20%).

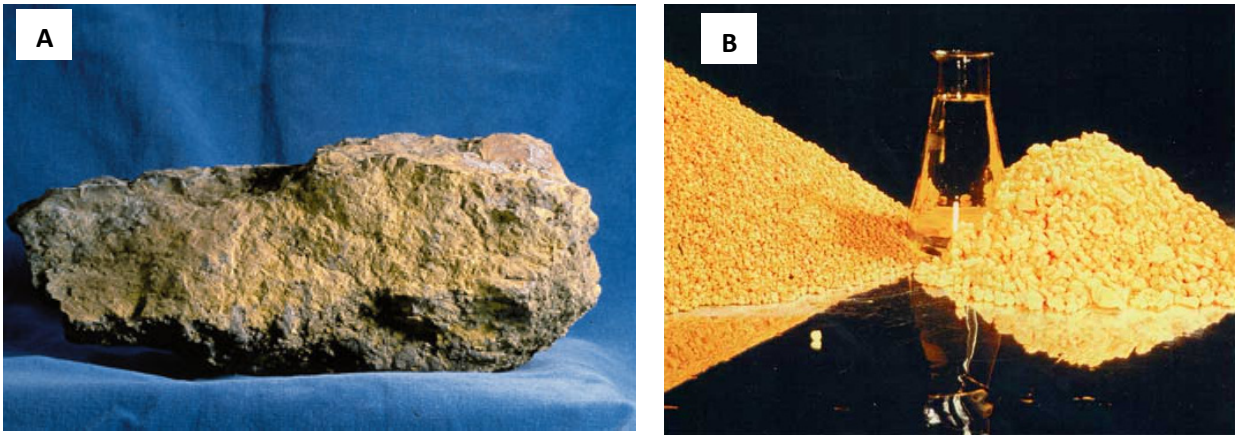


Figure 4.13: A) Uranium ore B) Yellowcake (U_3O_8). Images obtained from United States Geological Survey (A) and United States Department of Energy (B).

Uranium ore from a conventional mine is usually refined into uranium concentrate in a process referred to as **milling**. The ore is crushed and ground into fine powder that is then reacted with chemicals to separate the uranium from other minerals. The concentrated uranium product is typically a bright yellow or orange powder called *yellowcake* (U_3O_8) (Figure 4.13 B), and the waste stream from these operations is called *mill tailings*. Uranium ore in solution is also milled into yellowcake by retrieving the uranium out of the solution and concentrating it.

The yellowcake then undergoes **conversion** into uranium hexafluoride (UF_6) gas. This step enables the atomic segregation of the three naturally occurring uranium isotopes in to individual components. In the UF_6 gas, the original concentrations of uranium isotopes are still unchanged. This gas is then sent to an **enrichment** plant where the isotope separation takes place and the concentration of U-235 is increased to about a 4% to 5% (compared to 0.72 % original concentration). The product, called *enriched* UF_6, is sealed in canisters and allowed to cool and solidify before it is transported to a fuel assembly plant.

The next step in the production of nuclear fuel takes place at fuel **fabrication** facilities. Here, the enriched UF_6 gas is reacted to form a black uranium dioxide (UO_2) powder. The powder is then compressed and formed into the shape of small ceramic *fuel pellets* (Figure 4.14 A). Each ceramic pellet produces roughly the same amount of energy as 150 gallons of oil. The pellets are stacked and sealed into long metal tubes that are about 1 centimeter in diameter to form **fuel rods**. (Figure 4.14 B) fuel rods are then bundled together to make up a *fuel assembly*

(Figure 4.14 C). Depending on the reactor type, there are about 179 to 264 fuel rods in each fuel assembly. A typical reactor core holds 121 to 193 fuel assemblies.

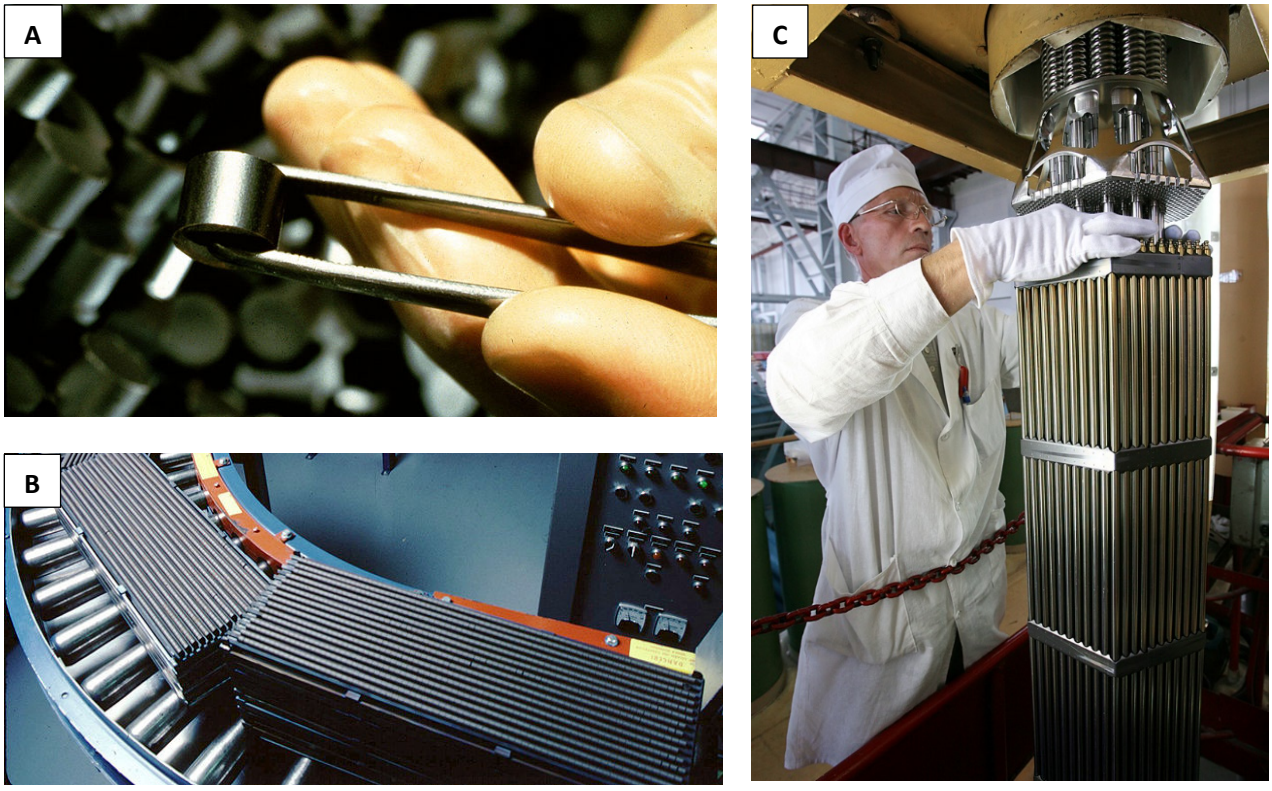


Figure 4.14: Fuel fabrication process. A) Uranium dioxide powder compressed into *fuel pellets*. B) Fuel pellets stacked and sealed in metal tubes forming *fuel rods*. C) Fuel rods are bundled into a *fuel assembly*. Images A and B from NRC (public domain); C from RIA Novosti archive, image #132602 / Ruslan Krivobok / CC-BY-SA 3.0

4.7.2 Nuclear Power Plant

After fabrication, fuel assemblies are transported to nuclear power plants where they are used as a source of energy for generating electricity. They are stored onsite until they are needed by the reactor operators. At this stage, the uranium is only mildly radioactive, and essentially all radiation is contained within the metal tubes. When needed, the fuel is loaded into a reactor core (Figure 4.15). Typically, about one third of the reactor core (40 to 90 fuel assemblies) is changed out every 12 to 24 months.

The most common type of reactors are the **pressurized water reactors** (PWR) (Figure 4.15) in which water is pumped through the *reactor core* and heated by the fission process. The water is kept under high pressure inside the reactor so it does not boil. The heated water from the reactor passes through tubes inside the *steam generator* where the heat is transferred to water flowing around the tubes in the steam generator. The water in the steam generator boils and turns to steam. The steam is piped to the turbines. The force of the expanding steam drives the turbines, which spin a magnet in coil of wire – the generator– to produce electricity.

After passing through the turbines, the steam is converted back to water by circulating it around tubes carrying cooling water in the *condenser*. The condensed steam – now water – is returned to the steam generators to repeat the cycle.

The three water systems (condenser, steam generator, and reactor) are separate from each other and are not permitted to mix. Water in the reactor is radioactive and is contained within the containment structure whereas water in the steam generator and condenser is nonradioactive.

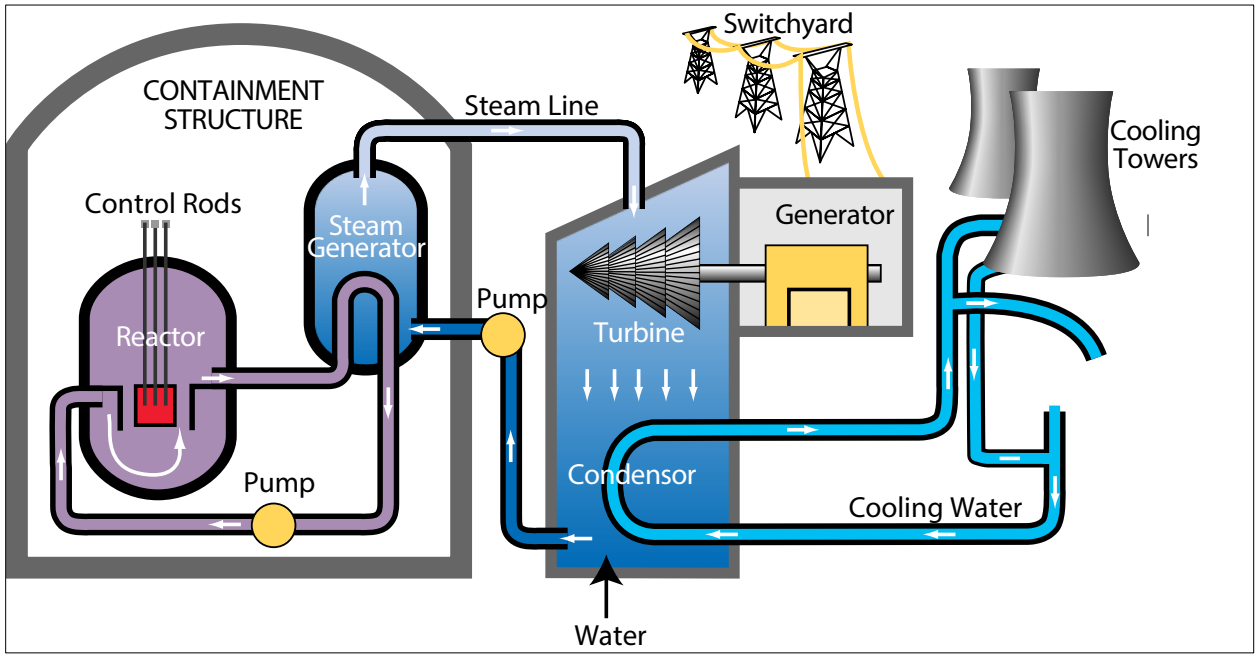


Figure 4.15: A schematic diagram of a pressurized water reactor (PWR), the most common type of nuclear reactor. Diagram from Tennessee Valley Authority (public domain). www.tva.com

4.7.3 Benefits of Nuclear Energy

By using fission, nuclear power plants generate electricity without emitting air pollutants like those emitted by fossil fuel-fired power plants. This means that financial costs related to chronic health problems caused by air pollutants such as particulate material, carbon monoxide, nitrogen oxides and ozone among others are significantly reduced. In addition nuclear reactors do not produce carbon dioxide while operating which means that nuclear energy does not contribute to the global warming problem.

Another benefit of nuclear energy over fossil fuels especially coal is that uranium generates far more power per unit weight or volume. This means that less of it needs to be mined and consequently the damage to the landscapes is less especially when compared to the damage that results from coal mining such as mountaintop removal.

4.7.4 The Drawbacks of Nuclear Energy

The main environmental concern related to nuclear power is the creation of radioactive wastes such as uranium mill tailings, spent (used) reactor fuel, and other radioactive wastes. These materials can remain radioactive and dangerous to human health for thousands of years. Radioactive wastes are classified as low-level and high-level. By volume, most of the waste

related to the nuclear power industry has a relatively low-level of radioactivity. Uranium mill tailings contain the radioactive element radium, which decays to produce **radon**, a radioactive gas. Most uranium mill tailings are placed near the processing facility or mill where they come from. Uranium mill tailings are covered with a barrier of material such as clay to prevent radon from escaping into the atmosphere, and they are then covered by a layer of soil, rocks, or other materials to prevent erosion of the sealing barrier.

The other types of low-level radioactive waste are the tools, protective clothing, wiping cloths, and other disposable items that get contaminated with small amounts of radioactive dust or particles at nuclear fuel processing facilities and power plants. These materials are subject to special regulations that govern their handling, storage, and disposal so they will not come in contact with the outside environment.

High-level radioactive waste consists of spent nuclear reactor fuel (i.e., fuel that is no longer useful for producing electricity). The spent reactor fuel is in a solid form consisting of small fuel pellets in long metal tubes called rods. Spent reactor fuel assemblies are initially stored in specially designed pools of water, where the water cools the fuel and acts as a radiation shield. Spent reactor fuel assemblies can also be stored in specially designed dry storage containers. An increasing number of reactor operators now store their older spent fuel in dry storage facilities using special outdoor concrete or steel containers with air cooling. There is currently no permanent disposal facility in the United States for high-level nuclear waste.

When a nuclear reactor stops operating, it must be **decommissioned**. This involves safely removing the reactor and all equipment that has become radioactive from service and reducing radioactivity to a level that permits other uses of the property. The U.S. Nuclear Regulatory Commission has strict rules governing nuclear power plant decommissioning that involve cleanup of radioactively contaminated plant systems and structures, and removal of the radioactive fuel.

A **nuclear meltdown**, or uncontrolled nuclear reaction in a nuclear reactor, can potentially result in widespread contamination of air and water. Some serious nuclear and radiation accidents have occurred worldwide. The most severe accident was the Chernobyl accident of 1986 in the then Soviet Union (now Ukraine) which killed 31 people directly and sickened or caused cancer in thousands more. The Fukushima Daiichi nuclear disaster (2011) in Japan was caused by a 9.0 magnitude earthquake that shut down power supply and a tsunami that flooded the plant's emergency power supply. This resulted in the release of radioactivity although it did not directly result in any deaths at the time of the disaster. Another nuclear accident was the Three Mile Island accident (1979) in Pennsylvania, USA. This accident resulted in a near disastrous core meltdown that was due to a combination of human error and mechanical failure but did not result in any deaths and no cancers or otherwise have been found in follow up studies of this accident. While there are potentially devastating consequences to a nuclear meltdown, the likelihood of one occurring is extremely small. After every meltdown, including the 2011 Fukushima Daiichi disaster, new international regulations were put in place to prevent such an event from occurring again.

The processes for mining and refining uranium ore and making reactor fuel require large amounts of energy. Nuclear power plants have large amounts of metal and concrete, which also require large amounts of energy to manufacture. If fossil fuels are used for mining and refining uranium ore or in constructing the nuclear plant, then the emissions from burning those fuels could be associated with the electricity that nuclear power plants generate.

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U.S. Environmental Protection Agency www.epa.gov

Terms list

Acid mine drainage
Anaerobic
Ash
Boiler
Caprocks
Carbon capture & sequestration
Carbon dioxide
Carbon monoxide
Chain reaction
Chemical energy
Clean Air Act
Clean coal technology
Clean Water Act
Coal
Coal-fire power plant
Condenser
Conversion
Crude
Decommissioned
Digesters
Electricity
Energy
Enrichment
Exploration
Fabrication
Fossil fuel
Fuel rods
Furnace
Generator
Greenhouse gas
Heating value
Heavy metals
Hydraulic fracturing
Hydrocarbon
Isotope
Kinetic energy
Liquid natural gas
Mercury
Methane
Methylmercury
Milling
Mountaintop removal
Natural gas
Neutron
Nitrogen oxides
Non-renewable
Nuclear fission
Nuclear meltdown
Nucleus
Offshore
Oil
Oil spill
Onshore
Ore
Overburden
Particulate matter
Petroleum
Pipeline
Plastic
Potential energy
Pressurized water reactors
Primary energy
Radiation
Radon
Reclaimed
Refinery
Scrubber
Secondary energy

Separation
Strip mining
Sulfur dioxide
Transporation
Treatment
Turbine
U-235
Underground mining
Uranium
Volatile organic
compounds

Chapter 5: Alternative energy

Learning outcomes - by the end of this chapter, students should be able to.

1. Describe arguments for alternative energy
2. Explain the following aspects of solar energy:
    a. How passive solar energy works and provide examples of its use.
    b. How solar panels (photovoltaic cells) work.
    c. The limitations and environmental costs associated with solar energy.
3. Explain the following aspects of biofuels / biomass energy:
    a. Describe what is meant by the term "carbon neutral" and explain how biomass energy can and cannot be carbon neutral.
    b. Describe current achievements in biofuels and potential of this area for growth.
4. Describe wind energy and explain the advantages and disadvantages.
5. Describe geothermal energy and explain the advantages and disadvantages
6. Describe hydroelectric energy, advantages and disadvantages

Chapter Outline

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5.1 INTRODUCTION

Energy sources that are more or less continuously made available in a time frame useful to people are called **renewable energy**. Renewable energy sources are often considered alternative sources because, in general, most industrialized countries do not rely on them as their main energy source. Instead, they tend to rely on the conventional energy sources such as fossil fuels or nuclear power that are non-renewable. Because of the energy crisis in the United States during the 1970s, dwindling supplies of fossil fuels and hazards associated with nuclear power, use of renewable energy sources such as solar energy, hydroelectric, wind, biomass, and geothermal has grown. Renewable energy comes from the sun (considered an "unlimited" supply) or other sources that can theoretically be renewed at least as quickly as they are consumed. If used at a sustainable rate, these sources will be available for consumption for thousands of years or longer. Renewable alternatives derive from wind, water, solar or biomass (**Figure 5.1**). Note that wind, water and biomass energy sources are indirect sources of solar energy. One limitation currently associated with most forms of renewable energy is that the energy is not concentrated and not easily portable.



Figure 5.1 A variety of voltage sources (clockwise from top left): the Brazos Wind Farm in Fluvanna, Texas (credit: Leaflet, Wikimedia Commons); the Krasnoyarsk Dam in Russia (credit: Alex Polezhaev); a solar farm (credit: U.S. Department of Energy); and a group of nickel metal hydride batteries (credit: Tiaa Monto). The voltage output of each depends on its construction and load, and equals emf only if there is no load.

Energy is an important ingredient in all phases of society. We live in a very interdependent world, and access to adequate and reliable energy resources is crucial for economic growth and for maintaining the quality of our lives. However, current levels of energy consumption and production are not sustainable because of the heavy reliance on non-renewable energy sources. The principal energy resources used in the world are shown in **Figure 5.2**. The

fuel mix has changed over the years but now is dominated by oil, although natural gas and solar contributions are increasing. About 80 % of our energy comes from nonrenewable fossil fuels and nuclear. The link between global warming and fossil fuel use, with its production of carbon dioxide through combustion, has made, in the eyes of many scientists, a shift to non-fossil fuels of utmost importance – but it will not be easy. About 40 % of the world's energy comes from oil, and much of that goes to transportation uses.

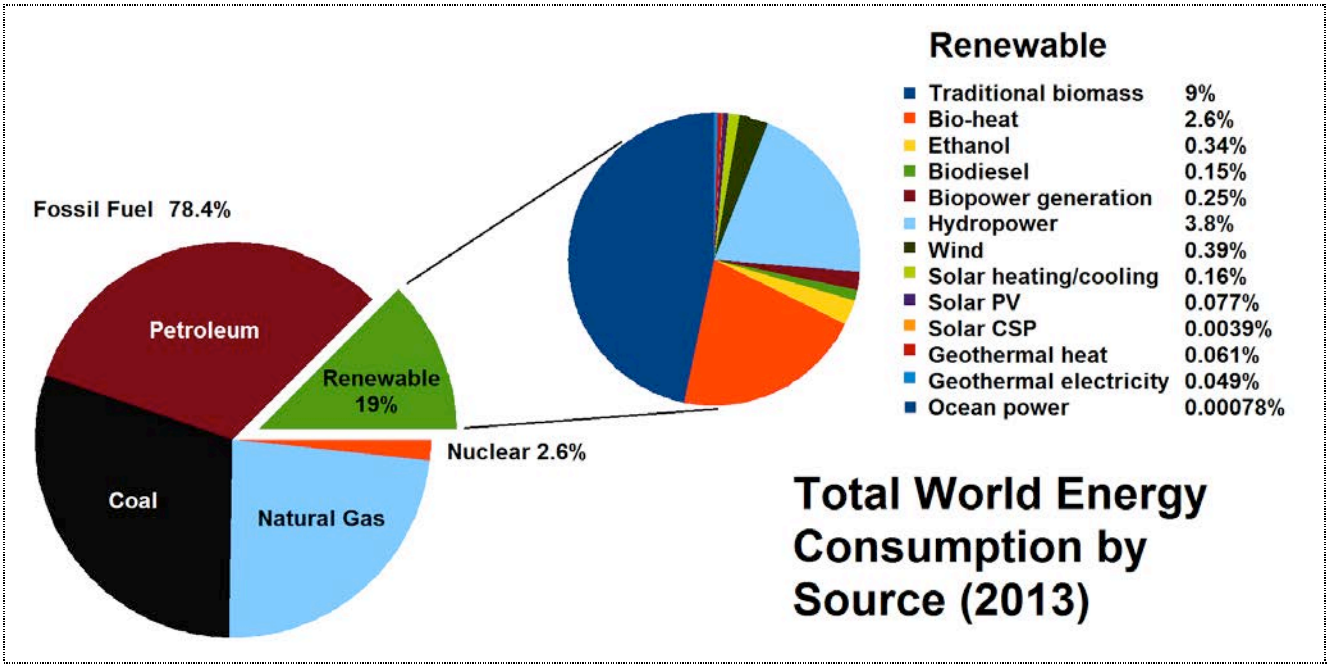


Figure 5.2. World energy consumption by source, 2013, in percent. Notice that when all forms of biomass energy are combined, biomass makes up the largest proportion of renewable energy used worldwide. Source: Wikimedia commons - By Delphi234 - Own work, CC0, https://commons.wikimedia.org/w/index.php?curid=33567170

5.1.1 The World's Growing Energy Needs

World energy consumption continues to rise especially in countries like China where the economy is improving. Global demand for energy has tripled in the past 50 years and might triple again in the next 30 years (**Figure 5.3**). While much of this growth will come from the rapidly booming economies of China and India, many of the industrialized countries, especially those in Europe, are hoping to meet their energy needs by expanding the use of renewable sources. Although presently only a small percentage, renewable energy is growing very fast, especially wind energy. For example, Germany plans to meet 20% of its electricity and 10% of its overall energy needs with renewable resources by the year 2020. Energy is a key constraint in the rapid economic growth of China and India. In 2003, China surpassed Japan as the world's second largest consumer of oil. However, over 1/3 of this oil is imported. Unlike most Western countries, coal dominates the commercial energy resources of China, accounting for 2/3 of its energy consumption. In 2009 China surpassed the United States as the largest emitter of CO_2. In India, the main energy resources are biomass (wood and dung) and coal. Half of India's oil is imported. About 70% of India's electricity is generated by highly polluting coal. Yet there are

sizeable strides being made in renewable energy. India has a rapidly growing wind energy base, and it has the largest solar cooking program in the world. While non-renewable sources dominate, some countries get a sizeable percentage of their electricity from renewable resources. For example, about 67% of New Zealand's electricity demand is met by hydroelectric. Renewable resources, primarily hydroelectric, generate only 10% of the U.S. electricity.

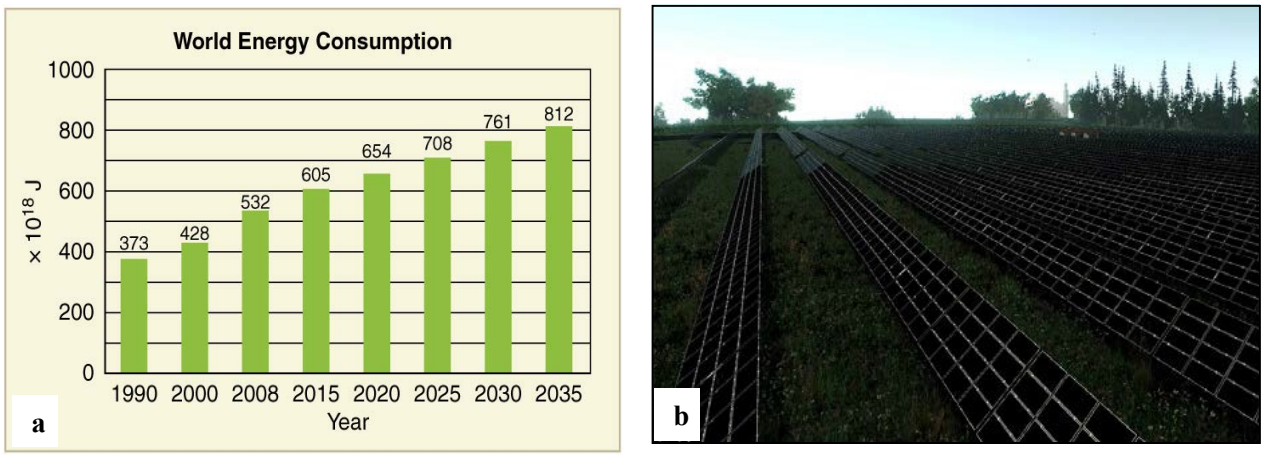


Figure 5.3: (**a**) Past and projected world energy use (source: Based on data from U.S. Energy Information Administration, 2011). (**b**) Solar cell arrays at a power plant in Steindorf, Germany (credit: Michael Betke, Flickr).

5.1.2 Why Use Renewable Energy Sources?

Majority of renewable energy sources including solar, wind, water, and biomass can be directly or indirectly attributed to the sun. The fact that the sun will continue burning for another 4-5 billion years makes it inexhaustible as an energy source for human civilization. With appropriate technology, renewable energy sources allow for local, decentralized control over power. Homes, businesses, and isolated communities can use sources such as solar to produce electricity without being near a power plant or being connected to a grid. This eliminates problems such as spills associated with extraction and transportation of fossil fuels that is needed in order to supply these fossil fuels to those areas that are lacking. Most renewable energy sources do not pollute the air with greenhouse gas emissions and other air pollutants associated with fossil fuels. This is especially important in combating climate change.

5.2 SOLAR ENERGY

Solar energy is the ultimate energy source driving life on earth and many human activities. Though only one billionth of the energy that leaves the sun (**Figure 5.4**) actually reaches the earth's surface, this is more than enough to meet the world's energy requirement. In fact, all other sources of energy, renewable and non-renewable, are actually stored forms of solar energy. The process of directly converting solar energy to heat or electricity is considered a renewable energy source. Solar energy represents an essentially unlimited supply of energy as the sun will long outlast human civilization on earth. The difficulties lie in harnessing the energy. Solar energy has been used for centuries to heat homes and water, and modern technology

(photovoltaic cells) has provided a way to produce electricity from sunlight. There are two basic forms of solar energy collectors are passive and active.

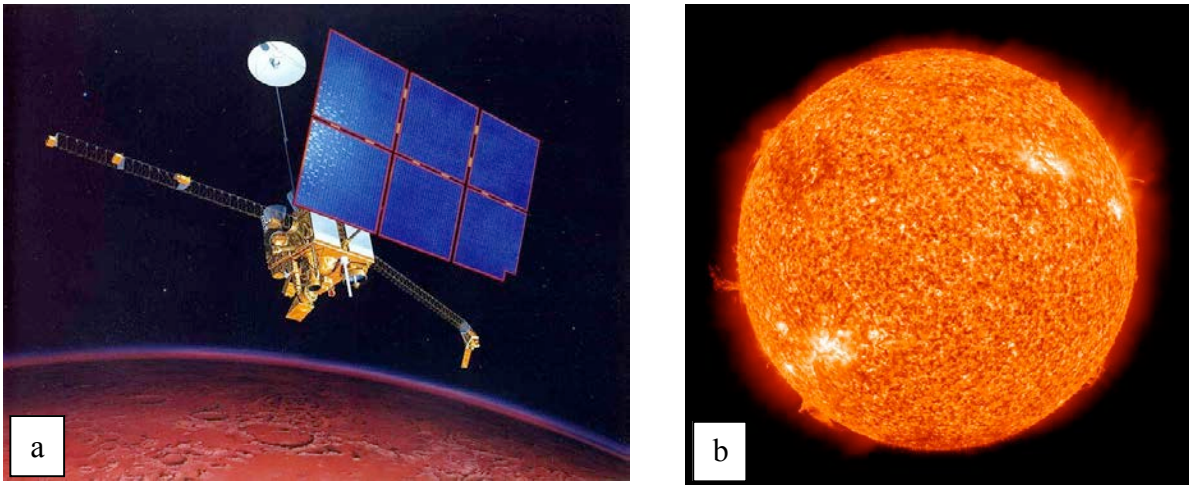


Figure 5.4. a) Mars Observer in Mars Orbit showing the solar panel. (Picture: Wikimedia Commons http://www.jpl.nasa.gov/images/spacecraft/marsobserver/craft1-browse.jpg,). b) The Sun photographed at 304 angstroms by the Atmospheric Imaging Assembly (AIA 304) of NASA's Solar Dynamics Observatory (SDO). This is a false-color image of the Sun observed in the extreme ultraviolet region of the spectrum.
http://sdo.gsfc.nasa.gov/assets/img/browse/2010/08/19/20100819_003221_4096_0304.jpg, NASA/SDO (AIA)

5.2.1 Passive and Active Solar Energy

Passive solar energy uses heating and cooling strategies that have been used historically such as natural ventilation, solar heat gain, solar shading and efficient insulation. Passive solar space heating happens when the sun shines through the windows of a building and warms the interior (**Figure 5.5**). Building designs that optimize passive solar heating usually have south-facing windows that allow the sun to shine on solar heat-absorbing walls or floors during the winter. The solar energy heats the building by natural radiation and convection and the heat is trapped, absorbed and stored by materials with high thermal mass (usually bricks or concrete) inside the house. The heat is released at night when needed to warm up the building as it loses heat to the cooler outdoors. Window overhangs or shades block the sun from entering the windows during the summer to keep the building cool.

Active solar energy systems require the input of some energy to pump a heat-absorbing fluid medium through a *collector* to store and distribute the energy. Fans or pumps circulate air or heat-absorbing liquids through collectors and then transfer the heated fluid directly to a room or to a heat storage system. The solar collectors are either concentrating or non-concentrating. In the **non-concentrating collectors**, the surface area that intercepts the solar radiation is the same as the area absorbing the radiation. *Flat-plate collectors* are the most common type of non-concentrating collectors and are used when temperatures lower than 200°F are sufficient. The collectors absorb and transfer heat to a fluid (water or air) which is then circulated to provide heating to a building. In **concentrating collectors** the surface area intercepting the solar radiation is greater, sometimes hundreds of times greater, than the absorber area. The collector

focuses or concentrates solar energy onto an absorber. The collector usually moves so that it maintains a high degree of concentration on the absorber.



Figure 5.5. Passive solar building near Crestone, Colorado (image from Wiki Commons)

Photovoltaic (PV) Cells

Solar photovoltaic (PV) devices, or solar cells, change sunlight directly into electricity. PV uses semiconducting materials such as silicon to produce electricity from sunlight: when light hits the cells, the material produces free electrons that migrate across the cell, creating an electric current. Small PV cells can power calculators, watches, and other small electronic devices. Arrangements of many solar cells in PV panels and arrangements of multiple PV panels in PV arrays can produce electricity for an entire house (**Figure 5.6a**). Some PV power plants have large arrays that cover many acres to produce electricity for thousands of homes.

Hundreds of thousands of houses and buildings around the world have PV systems on their roofs. Many multi-megawatt PV power plants have also been built. Covering 4% of the world's desert areas with photovoltaics could supply the equivalent of all of the world's electricity. The Gobi Desert alone could supply almost all of the world's total electricity demand.

Solar Thermal Power Plants

Solar thermal power plants, like the one in **Figure 5.6b** use concentrating solar collector systems to collect and concentrate sunlight to produce the high temperature heat needed to generate electricity. All solar thermal power systems have solar energy collectors with two main components: *reflectors* (mirrors) that capture and focus sunlight onto a *receiver*. In most types of systems, a heat-transfer fluid is heated and circulated in the receiver and used to produce steam. The steam is converted into mechanical energy in a turbine, which powers a generator to produce electricity. Solar thermal power systems have tracking systems that keep sunlight focused onto the receiver throughout the day as the sun changes position in the sky.

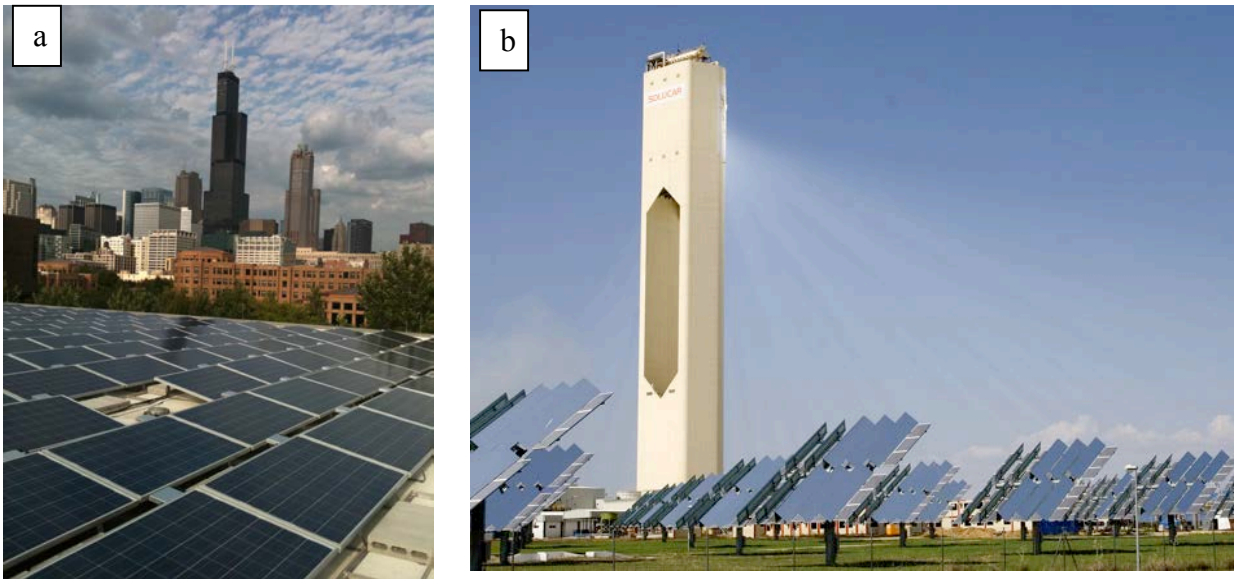


Figure 5.6: a) Rooftop Solar Installations on Douglas Hall at the University of Illinois at Chicago has no effect on land resources, while producing electricity with zero emissions. Source: Office of Sustainability. **b**) Solucar PS10 solar power tower in Andalusia, Spain, is a solar thermal power plant that generates electricity commercially. (Photo by Afloresm Solucar PS10 CC BY 2.0)

5.2.3 Environmental Impacts of solar energy

Solar power has minimal impact on the environment, depending on where it is placed. In 2009, one percent of the renewable energy generated in the United States was from solar power (1646 MW) out of the eight percent of the total electricity generation that was from renewable sources. The manufacturing of photovoltaic (PV) cells generates some hazardous waste from the chemicals and solvents used in processing. Often solar arrays are placed on roofs of buildings or over parking lots or integrated into construction in other ways. However, large systems may be placed on land and particularly in deserts where those fragile ecosystems could be damaged if care is not taken. Some solar thermal systems use potentially hazardous fluids (to transfer heat) that require proper handling and disposal. Concentrated solar systems may need to be cleaned regularly with water, which is also needed for cooling the turbine-generator. Using water from underground wells may affect the ecosystem in some arid locations.

5.3 BIOMASS ENERGY

Biomass energy is from the energy stored in materials of biological origin such as plants and animals. Biomass energy is the oldest energy source used by humans. Until the Industrial Revolution prompted a shift to fossil fuels in the mid-18th century, biomass energy was the world's dominant fuel source. It includes *direct combustion* of solid biomass to provide energy for heating, cooking, and even generating electricity. The most common source for direct combustion is wood, but energy can also be generated by burning animal manure (dung), herbaceous plant material (non-wood), peat (partially decomposed plant and animal tissues), or converted biomass such as charcoal (wood that has been partially burned to produce a coal-like

substance). Biomass can also be converted into a *liquid biofuels* used to power vehicles such as ethanol from corn, sugarcane residue and soybeans or even used cooking oil for biodiesel. Biomass energy can also be in *gaseous* form such as methane. Currently, about 12 percent of the world's energy comes from biomass (**Figure 5.2**). Biomass is most frequently used as a fuel source in many developing nations, but with the decline of fossil fuel availability and the increase in fossil fuel prices, biomass is increasingly being used as a fuel source even in developed nations.

5.3.1 Direct combustion of solid biomass

Using wood and charcoal made from wood, for heating and cooking can replace fossil fuels and may result in lower CO_2 emissions. If wood is harvested from forests or woodlots that have to be thinned or from urban trees that fall down or needed be cut down anyway, then using it for biomass does not impact those ecosystems. However, wood smoke contains harmful pollutants like carbon monoxide and particulate matter. For home heating, it is most efficient and least polluting when using a modern wood stove or replace insert that are designed to release small amounts of particulates. However, in places where wood and charcoal are major cooking and heating fuels such as in industrializing countries, the wood may be harvested faster than trees can grow resulting in deforestation.

Biomass is also being used on a larger scale, where small power plants are powered by biomass such as woodchips (**Figure 5.7**). For instance, Central State Hospital, Milledgeville, GA has a woodchip burning plant that was the most advanced system available for its time and operating today. Colgate University in Hamilton, New York, has had a wood-burning boiler since the mid-1980's that processes about 20,000 tons of locally and sustainably harvested wood chips, the equivalent of 1.17 million gallons (4.43 million liters) of fuel oil, avoiding 13,757 tons of emissions, and saving the university over $1.8 million in heating costs. The University's steam-generating wood-burning facility now satisfies more than 75 percent of the campus's heat and domestic hot water needs. For more information about this, click here Colgate University.



Figure 5.7. A biomass (woodchip) power plant in Germany. Image from Wikimedia Public Domain.

Waste products of various industries and processes such as lumber mill sawdust, paper mill sludge, yard waste, oat hulls from an oatmeal processing plant, woody debris from logging, organic waste from feedlots, and residue from crops can also be used for energy. Waste to energy processes are gaining renewed interest as they can solve two problems at once: 1) disposal of waste as landfill capacity decreases; and 2) production of energy from a renewable resource. In the United States, several plants have been constructed to burn urban biomass waste and use the energy to generate electricity. Many of the environmental impacts are similar to those of a coal plant like air pollution, ash generation, etc. Since the fuel source is less standardized than coal and hazardous materials may be present in municipal solid waste (MSW), or garbage, incinerators and waste-to-energy power plants need to clean the stack gases of harmful materials. The U.S. EPA regulates these plants very strictly and requires anti-pollution devices to be installed. If not contained, waste is distributed in many ecosystems. The ash from these plants may contain high concentrations of various metals that were present in the original waste. If ash is clean enough it can be recycled as a MSW landfill cover or to build roads, cement block and artificial reefs. Also, while incinerating at high temperature many of the toxic chemicals may break down into less harmful compounds.

5.3.2 Gaseous Biomass

Organic material can be converted to methane, the main component of natural gas, by anaerobic decomposition or fermentation, a process that utilizes anaerobic bacteria. Methane is a relatively clean fuel that burns efficiently. It can be generated from any kind of organic waste such as municipal sewage and garbage, livestock manure, kitchen, and garden scraps. In fact, municipal landfills are active sites of methane production contributing annually to methane in the atmosphere and to global warming. This gas can and is currently being captured by numerous landfills around the United States that burn it to generate electricity at power plants or supply it to homes for heating. The electricity may replace electricity produced by burning fossil fuels and result in a net reduction in CO_2 emissions. Burning methane produced from manure provides more heat than burning the dung itself, and the sludge left over from bacterial digestion is a rich fertilizer, containing healthy bacteria as well as most of the nutrients originally in the dung. The main environmental impacts are from the construction of the plant itself. Burning methane releases CO_2 and although CO_2 is a greenhouse gas, its global warming potential is much lower than that of methane (see chapter 7). Also, since this methane if from organic waste resulting from ongoing photosynthetic processes, it is considered carbon-neutral, unlike CO_2 from fossil fuels.

5.3.3 Liquid Biofuels

Biofuels are transportation fuels produced from plant sources and used to power vehicles. The most common ones are ethanol and biodiesel. **Ethanol**, also known as ethyl alcohol or grain alcohol, is produced by fermenting crops such as corn, sugarcane, and other crops and then mixed with conventional gasoline. As an additive, ethanol lowers reliance on conventional oil and increases the combustion efficiency of gasoline, reducing pollutant emissions. In Brazil, which has a sizeable ethanol industry based on sugarcane, all gasoline sold contains 25 percent alcohol, and over 70 percent of the cars sold each year can run on either ethanol or gasoline. Ethanol-gasoline mixtures burn cleaner than pure gasoline but are more volatile and thus have higher "evaporative emissions" from fuel tanks and dispensing equipment. These emissions

contribute to the formation of harmful, ground level ozone and smog. Gasoline requires extra processing to reduce evaporative emissions before it is blended with ethanol.

Biodiesel which is essentially vegetable oil, can also be derived from a wide range of plant sources, including rapeseed, sunflowers, and soybeans, and can be used in most conventional diesel engines. Biodiesel can also be made from used vegetable oil and has been produced on a very local basis. Because it burns more cleanly than its petroleum-based counterpart, biodiesel can reduce pollution from heavy-duty vehicles such as trucks and buses. Compared to petroleum diesel, biodiesel combustion produces less sulfur oxides, particulate matter, carbon monoxide, and unburned and other hydrocarbons, but more nitrogen oxide.

Calculating the net energy or CO_2 generated or reduced in the process of producing the biofuel is crucial to determining its environmental impact. Biofuels may be derived from parts of plants not used for food (cellulosic biomass) thus reducing that impact. Cellulosic ethanol feedstock includes native prairie grasses, fast growing trees, sawdust, and even waste paper. Also, in some parts of the world, large areas of natural vegetation and forests have been cut down to grow sugarcane for ethanol and soybeans and palm-oil trees to make biodiesel. This is not sustainable land use.

Biomass energy may be considered to be **carbon-neutral** because the plants that are used to make them (such as corn and sugarcane for ethanol, or soy beans and palm oil trees for biodiesel) take up CO_2 from the atmosphere through photosynthesis as they grow and may offset the CO_2 produced when burned. If the biomass is not burned for energy generation, the carbon contained in the biomass would still be returned to the atmosphere as CO_2 when the organisms die and decompose to complete the cycle. Burning biomass, therefore, does not result in new additional CO_2 in the atmosphere but rather returns carbon that came from the atmosphere and used to produce the biomass in the first place. On the other hand, burning fossil fuels introduces new carbon into the atmosphere that was previously stored deep in the Earth's crust and would have stayed there if we (humans) did not extract it.

5.3.4 Environmental Impacts of Biomass Energy

A major challenge of biomass is determining if it is really a more sustainable option. The energy content of some biomass energy sources may not be as high as fossil fuels so more must be burned to generate the same energy. It often takes energy to make energy and biomass is one example where the processing to make it may not be offset by the energy it produces. If traditional monoculture crops like corn or soybeans are used, they require major quantities of fossil fuel to manufacture fertilizer, run farm machines, and ship the fuel to markets, so these biofuels do not always offer significant net energy savings over gasoline and diesel fuel. In such instances, biofuels may not be carbon-neutral because the process of producing the biofuels results in more CO_2 added to the atmosphere than that removed by the growing crops. Even if the environmental impact is net positive, for example if renewable energy sources are used to make the biofuels, the economic and social effects of growing plants for fuels need to be considered. The land, fertilizers, water, and energy used to grow biofuel crops could be used to grow food crops instead. The competition of land for fuel vs. food can increase the price of food, which has a negative effect on society. It could also decrease the food supply and increase malnutrition and starvation globally.

Trees that are cut for firewood are frequently not replanted. In order to be used sustainably, one tree must be planted for every one cut down. If too much biomass is taken it can reduce forest and grassland contributions to ecosystem services. Forests and grasslands help take

CO_2 out of the atmosphere through photosynthesis and the loss of photosynthetic activity results in increased amounts of CO_2 in the atmosphere and contribute to global warming since CO_2 is a greenhouse gas. Burning biomass directly (wood, manure, etc.) produces high particulate material pollution (see chapter 6 on Air Pollution), produces CO_2 and deprives the soil of nutrients it normally would have received from the decomposition of the organic matter. Each type of biomass energy source, therefore, must be evaluated for its full life-cycle impact in order to determine if it is really advancing sustainability and reducing environmental impacts.

5.4 WIND POWER

Wind is a renewable energy source that uses the power of moving air to generate electricity. Wind turbines use blades to collect the wind's kinetic energy. Wind flows over the blades creating lift (similar to the effect on airplane wings), which causes the blades to turn. The blades are connected to a drive shaft that turns an electric generator, which produces electricity (**Figure 5.8**). Wind turbines are becoming a more prominent sight across the United States, even in regions that are considered to have less wind potential. Wind turbines (often called windmills) do not release emissions that pollute the air or water (with rare exceptions), and they do not require water for cooling. The U.S. wind industry had 40,181 MW of wind power capacity installed at the end of 2010, with 5,116 MW installed in 2010 alone, providing more than 20 % of installed wind power around the globe. According to the American Wind Energy Association, over 35 % of all new electrical generating capacity in the United States since 2006 was due to wind, surpassed only by natural gas.

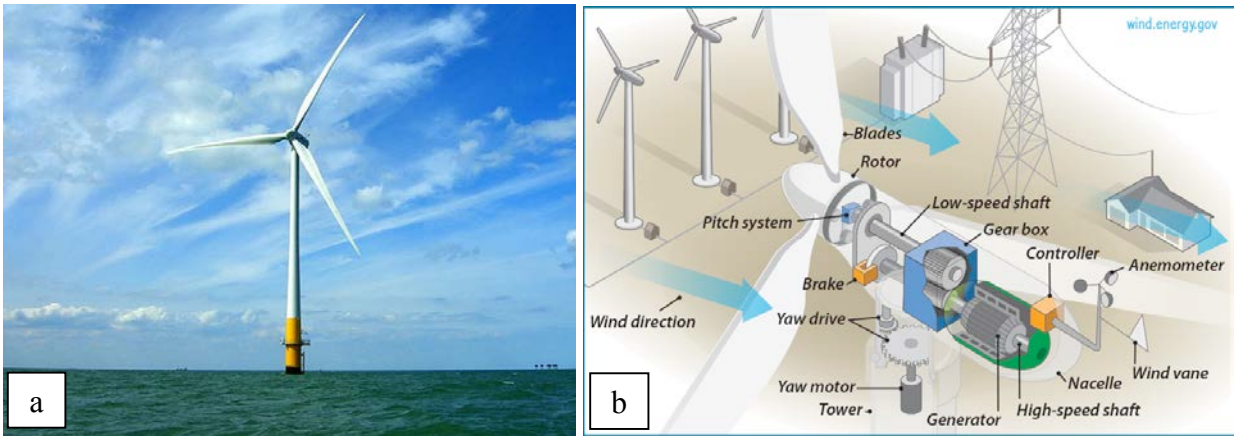


Figure 5.8. a) This wind turbine in the Thames Estuary in the UK is an example of induction at work, (credit: Phault, Flickr). Wind pushes the blades of the turbine, spinning a shaft attached to magnets, see image **b** for parts. The magnets spin around a conductive coil, inducing an electric current in the coil, and eventually feeding the electrical grid. Follow this link for an Animation.

Most windmills generate about 1kW of electricity, which is only practical for decentralized power generation. California has about 17,000 windmills with a capacity of about 1,400 MW. This is about 80% of all windmills in the U.S. In West Europe windmill generators are quite common. Since a wind turbine (**Figure 5.8**) has a small physical footprint relative to the amount of electricity it produces, many wind farms are located on crop, pasture, forest land, or coastal areas. They contribute to economic sustainability by providing extra income to farmers

and ranchers, allowing them to stay in business and keep their property from being developed for other uses. For example, energy can be produced by installing wind turbines in the Appalachian Mountains of the United States instead of engaging in mountain top removal for coal mining.

5.4.1 Environmental Impacts of Wind Energy

Off shore wind turbines on lakes or the ocean may have smaller environmental impacts than turbines on land. Wind turbines do have a few environmental challenges. There are aesthetic concerns to some people when they see them on the landscape. A few wind turbines have caught on fire, and some have leaked lubricating fluids, though this is relatively rare. Some people do not like the sound that wind turbine blades make.

Turbines have been found to cause bird and bat deaths particularly if they are located along their migratory path. This is of particular concern if these are threatened or endangered species. There are ways to mitigate that impact and it is currently being researched.

There are some small impacts from the construction of wind projects or farms, such as the construction of service roads, the production of the turbines themselves, and the concrete for the foundations. However, overall life cycle analysis has found that turbines make much more energy than the amount used to make and install them.

5.5 GEOTHERMAL ENERGY

Geothermal energy uses heat from the Earth's internal geologic processes in order to produce electricity or provide heating. The subsurface temperature of the Earth provides an endless energy resource. One source of geothermal energy is steam. Groundwater percolates down through cracks in the subsurface rocks until it reaches rocks heated by underlying magma, and the heat converts the water to steam. Sometimes this steam makes its way back to the surface in the form of a geyser or hot spring. Wells can be dug to tap the steam reservoir and bring it to the surface, to drive generating turbines and produce electricity (**Figure 5.9 a**). Hot water can be circulated to heat buildings. Regions near tectonic plate boundaries have the best potential for geothermal activity.

A geothermal system requires heat, permeability, and water. The heat from the Earth's core continuously flows outward. Sometimes the heat, as magma, reaches the surface as lava, but it usually remains below the Earth's crust, heating nearby rock and water — sometimes to levels as hot as 700°F. When water is heated by the earth’s heat, hot water or steam can be trapped in permeable and porous rocks under a layer of impermeable rock and a geothermal reservoir can form. Geothermal energy can be used for electricity production, for commercial, industrial, and residential direct heating purposes, and for efficient home heating and cooling through geothermal heat pumps.

To develop electricity from geothermal resources, wells are drilled into a geothermal reservoir. The wells bring the geothermal water to the surface, where its heat energy is converted into electricity at a geothermal power plant (**Figure 5.9 b**). Geothermal power plants do not burn fuel to generate electricity so their emission levels are very low.

a 

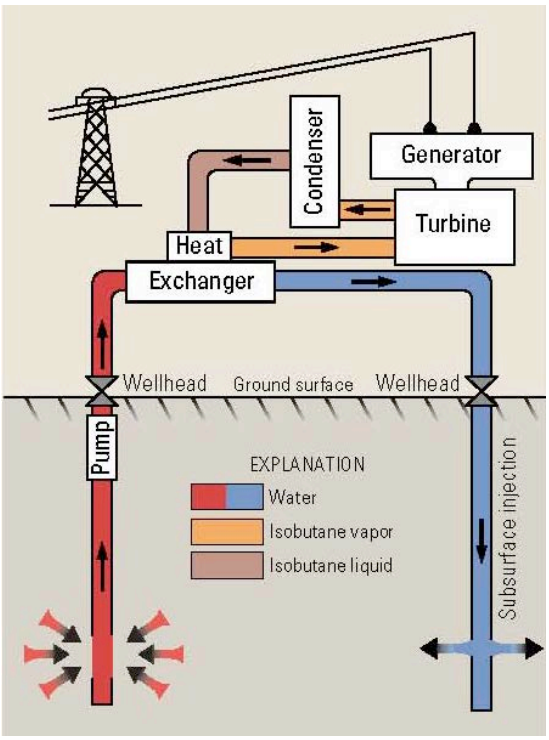
b 

Figure 5.9. **a**) Installing a Geothermal Pipe System Drilling to install geothermal ground source pipe system. Source: Office of Sustainability. **b**) Electricity generation at a moderate-temperature hydrothermal system. The geothermal water is used to boil a second fluid (isobutane in this example) whose vapor then drives a turbine generator. The wastewater is injected back into the subsurface. Source: USGS.

5.5.1 Environmental Impacts of Geothermal Energy

The environmental impact of geothermal energy depends on how it is being used. Direct use and heating applications have almost no negative impact on the environment. Geothermally heated water can release dissolved gases, including carbon dioxide, methane, ammonia and hydrogen sulfide, although these are usually in very small quantities when compared to those released from fossil fuel plants. In addition, geothermal plants use scrubber systems to clean the air of hydrogen sulfide that is naturally found in the steam and hot water. They emit 97 % less acid rain-causing sulfur compounds than are emitted by fossil fuel plants.

Even though geothermal energy is renewable, not every plant built to capture this energy will be able to operate indefinitely because the energy relies on groundwater recharge. If the heated water is used faster than the recharge rate of groundwater, the plant will eventually run out of water. The Geysers in California started experiencing this and operators responded by injecting municipal wastewater into the ground to replenish the supply. Also, patterns of geothermal activity in the Earth's crust naturally shift over time and an area that produces hot groundwater now may not always so do. The water of many hot springs is laced with salts and minerals that corrode equipment, shorten the lifetime of plants and increase maintenance costs.

Electrical power is restricted to regions where energy can be tapped from naturally heated groundwater but most areas of the world are not rich in naturally heated groundwater. Engineers are trying to overcome this by drilling deeply into dry rock, fracture the rock and pump in cold

water which becomes heated and drawn up through an outlet well and used to generate power. However, this approach is said to trigger minor earthquakes.

5.6 HYDROELECTRIC POWER (HYDROPOWER)

This is the second largest source of renewable energy used, next to biomass energy. Majority of hydropower currently comes from dams built across a river to block the flow of river water. The water stored behind the dam contains potential energy (see chapter 4) and when released, the potential energy is converted to kinetic energy as the water rushes down. This energy is used to turn blades of turbines and causing a generator to generate electricity. Electricity generated in the powerhouse of a dam is transmitted to the electric grid by transmission lines while the water flows into the riverbed below the dam and continues down river. An alternative approach considered less disruptive involves diverting a portion of the river's water through a pipe or channel and passed through a powerhouse to generate electricity and returned to the river. Another approach involves pumping water from a lower reservoir to a higher reservoir and then allowed to flow downhill through a turbine, generating electricity. This approach, however, requires energy input to pump the water.

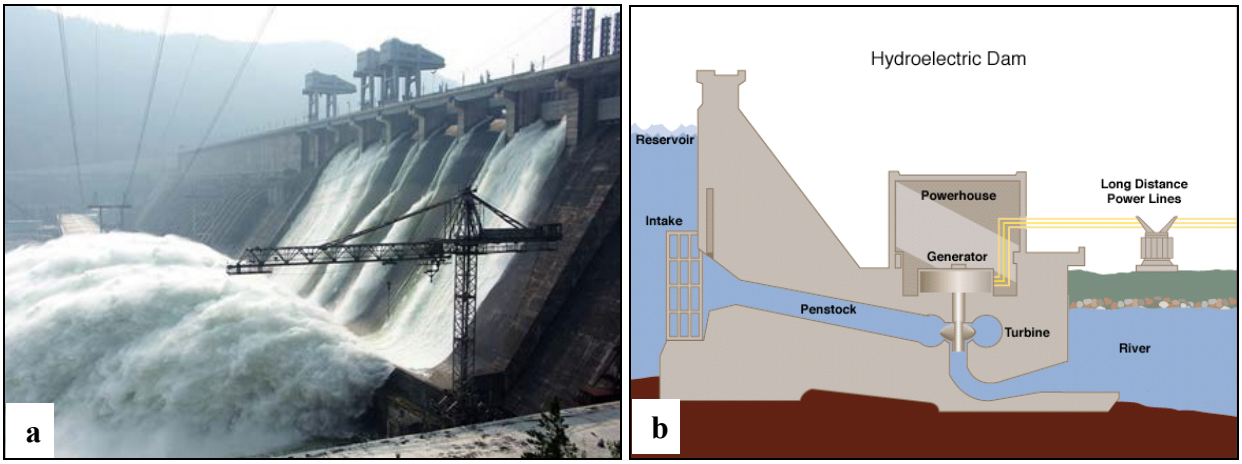


Figure 5.10. a) Hydroelectric facility (credit: Denis Belevich, Wikimedia Commons); **b)** An illustration showing how water is funneled through a portion of the dam to rotate turbines and generate electricity. (Image from Wikimedia, public domain).

Figure 5.11 shows the Hoover Power Plant located on the Colorado River. In the U.S., hydroelectric plants account for about 10% of total production and account for about 35 % of the United States' renewable energy consumption. In 2003 capacity was at 96,000 MW and it was estimated that 30,000 MW capacity is undeveloped. Energy produced can be calculated and modeled as shown in **Figure 5.12**.



Figure 5.11. a) A view of the Hoover dam from above (credit Adam Kliczek). **b)** Hydroelectric generators at the Hoover dam (credit: Jon Sullivan).

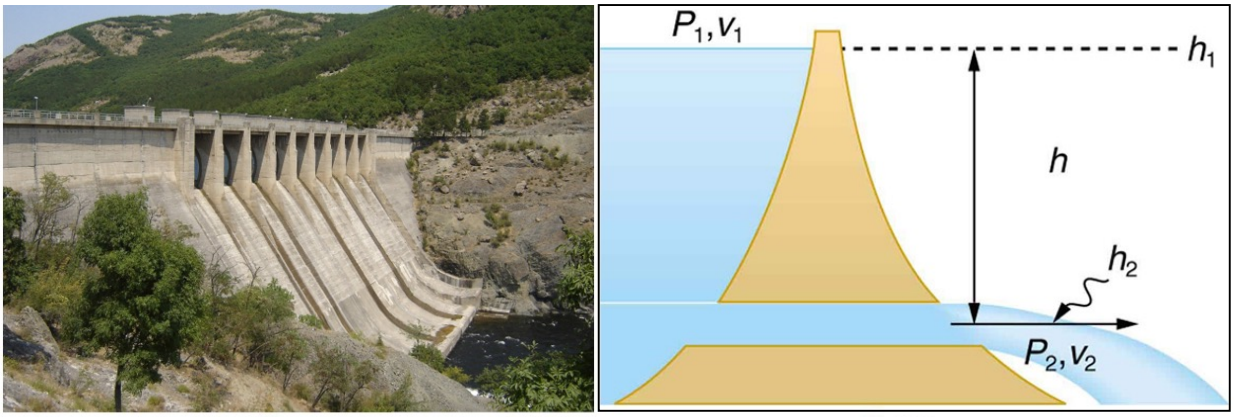


Figure 5.12. (a) Water gushes from the base of the Studen Kladenetz dam in Bulgaria. (credit: Kiril Kapustin; http://www.ImagesFromBulgaria.com) (b) In the absence of significant resistance, water flows from the reservoir with the same speed it would have if it fell the distance *h* without friction.

5.6.1 Environmental Impacts of Hydroelectric Power

Hydropower (hydro-electric) is considered a clean and renewable source of energy since it does not directly produce emissions of air pollutants and the source of power is regenerated. However, hydropower dams, reservoirs, and the operation of generators can have serious environmental impacts. A dam that is used to create a reservoir or to divert water to a run-of-river hydropower plant can obstruct migration of fish to their upstream spawning areas in areas where salmon must travel upstream to spawn, such as along the Columbia River in Washington and Oregon. Hydro turbines kill and injure some of the fish that pass through the turbine although there are ways to reduce that effect. This problem can be partially alleviated by using 'fish ladders' that help the salmon get up the dams.

A reservoir and operation of the dam can affect the natural water habitat due to changes in water temperatures, chemistry, flow characteristics, and silt loads, all of which can lead to

significant changes in the ecology and physical characteristics of the river upstream and downstream. Construction of reservoirs may cause natural areas, farms, and archeological sites to be covered and force populations to relocate and result in the loss of scenic rivers

Carbon dioxide and methane may also form in reservoirs where water is more stagnant and be emitted to the atmosphere. The exact amount of greenhouse gases produced from hydropower plant reservoirs is uncertain. If the reservoirs are located in tropical and temperate regions, including the United States, those emissions may be equal to or greater than the greenhouse effect of the carbon dioxide emissions from an equivalent amount of electricity generated with fossil fuels (EIA, 2011 p. 333).

5.6.2 Potential of Tidal Power

Tidal power involves placing turbines in zones of the ocean with significant tides and currents, and using the power of flowing water to turn the blades of a turbine to generate electricity. Ocean power systems are still being researched and currently still experimental. For example, the Bay of Fundy, which has a 15 m tide, a dam constructed across the estuary would let water enter on the incoming tide, then release the water through turbines at low tide. The energy potential is great http://www.ialtenergy.com/tidal-power-news.html , and so is the environmental cost. Tapping tidal energy resources involves building major dams on inlets and estuaries that are prized for other purposes, so few tidal energy facilities have been developed. Harnessing waves and currents on a significant scale will involve designing turbine structures that are large, inexpensive, and can operate for long periods under the physical stresses and corrosive forces of ocean environments. Though proposed, a tidal power plant has not been constructed at Fundy. There is a 240,000 kW tidal plant at La Rance, France.

5.7 OTHER ALTERNATIVE RENEWABLE ENERGY SOURCES

5.7.1 Hydrogen

Hydrogen gas may be an important clean fuel of the future. Hydrogen is considered an energy carrier, like electricity and batteries, it carries energy that can be converted for use later. Hydrogen gas does not tend to exist freely but rather hydrogen atoms bind to other atoms and molecules becoming incorporated in everything from water to organic compounds. Therefore, to obtain hydrogen gas for fuel, energy is needed to force these substances to release their hydrogen atoms. One such procedure is known as **electrolysis** in which an electric current is passed through water to decompose the water molecule into oxygen and hydrogen **(Figure 5.13)**. Hydrogen can also be produced from hydrocarbons such as natural gas and coal, fermentation of plant waste material, and using algae.

The nation of Iceland is attempting to become the first hydrogen based energy economy using its abundant geothermal energy resources. Some energy experts believe that combining hydrogen fuel and electricity could serve as a basis for a clean, safe, and energy efficient energy system. Electricity generated from intermittent renewable sources such as wind and solar can be used to produce hydrogen fuel for fuel cells that would then generate electricity to power vehicles, computers, heat homes and many other uses. An energy system based on hydrogen would alleviate dependence on foreign fuels and help fight climate change. Hydrogen is the most abundant element in the universe and we will never run out of it.

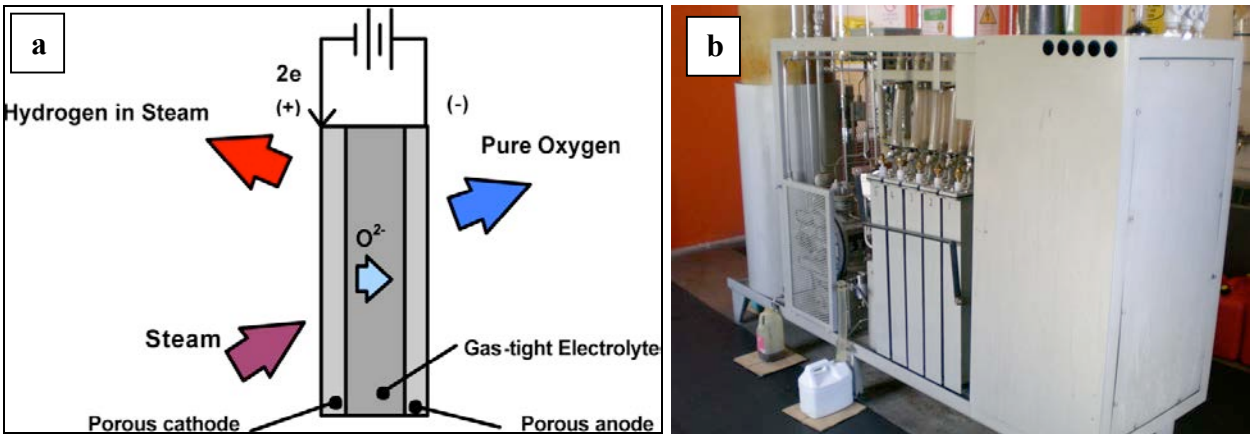


Figure 5.13 a) An electric current passed through water resulting in the separation of hydrogen atoms from oxygen to produce the hydrogen fuel. **b**) An electrolyser used in the production of hydrogen by CambridgeBayWeather. After production the hydrogen is used to inflate weather balloons to which a radiosonde is attached. The oxygen produced is vented to the outside.

Fuel Cells

Fuel cells are highly efficient power plants that produce electricity using hydrogen fuel in a chemical reaction that is a reverse of the electrolysis process that produced the hydrogen fuel (**Figure 5.14**). Energy is released by an exothermic electrochemical reaction that combines hydrogen and oxygen ions through an electrolyte material to generate electricity and heat. Experimental fuel cells that can power automobiles have been developed (**Figure 5.14**).



Figure 5.14: The electrochemical processes showing how hydrogen fuel is combined with oxygen generating heat energy along with water as a waste product. Some vehicles that use the fuel cell include buses (photo is a hydrogen fuel bus on Tower Bridge London, photo by Sludge G.), cars (The Toyota Fine N car based on fuel cell technology, photo by Chris 73, CC BY-SA 3.0) and motorcycles (Suzuki Burgman Fuel Cell cutaway model shown here, Photo by Mario CC BY-SA 3.0).

Challenges of Hydrogen

Currently, the infrastructure for using hydrogen fuel is lacking and converting a nation such as the United States to hydrogen would require massive and costly development of facilities to produce, store, transport, and provide the fuel. The environmental impact of hydrogen production itself depends on the source of material used to supply the hydrogen. For example, biomass and fossil fuel sources result in carbon-based emissions. Some research suggests that leakage of hydrogen from its production, transport, and use could potentially deplete stratospheric ozone. Research into this is still ongoing.

5.7.2 Electric cars

Electric cars are vehicles that solely depend on electricity to work. They are charged using fossil fuel energy sources (**Figure 5.15 a**), but they are very efficient. Although it might seem like science fiction the electric car is already here, and has been here for the last hundred years. The main problem with the electric car is that it cannot go very far before it needs to be recharged, something that takes between three to six hours. Different models have been explored (**Figure 5.15 b**), but for now most cars are equipped as a hybrid with a back up reservoir using fossil fuel.

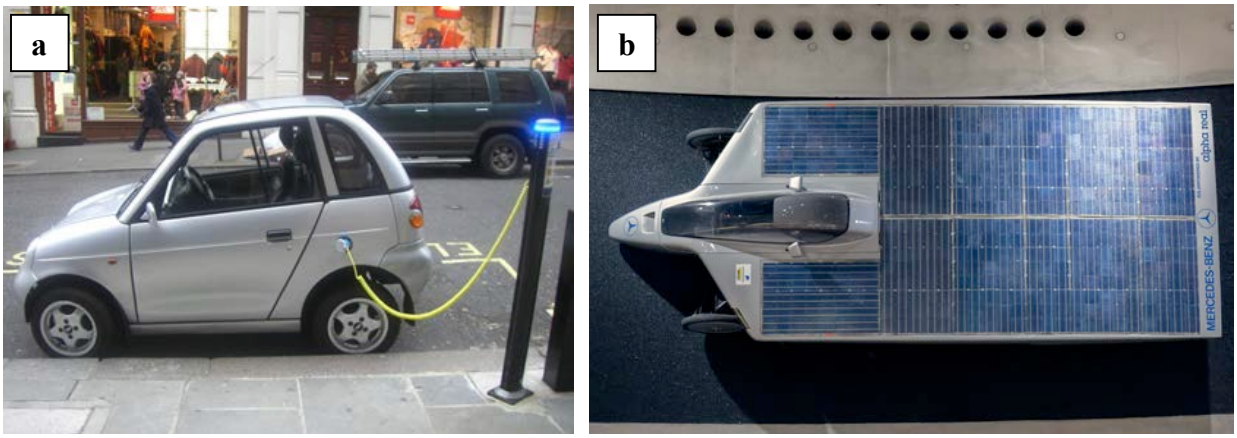


Figure 5.15. a) This REVAi, an electric car, gets recharged on a street in London. (credit: Frank Hebbert). **b**) 1985 Mercedes-Benz/Alpha Real "Tour de Sol" Solarmobile; built for the 1985 Tour de Sol Centennial Rally, solar car race from Lake Constance to Lake Geneva.

5.8 POLICY AND CONSERVATION

As we finish this chapter on energy and work, it is relevant to draw some distinctions between two sometimes misunderstood terms in the area of energy use. As has been mentioned elsewhere, the "*law of the conservation of energy*" is a very useful principle in analyzing physical processes. It is a statement that cannot be proven from basic principles, but is a very good bookkeeping device, and no exceptions have ever been found. It states that the total amount of energy in an isolated system will always remain constant. Related to this principle, but remarkably different from it, is the important philosophy of energy *conservation*. Conservation has to do with seeking to decrease the amount of energy used by an individual or a group through (1) reduced consumption (e.g., turning down thermostats, driving fewer kilometers) and/or (2)

increasing conversion efficiencies in the performance of a particular task—such as developing and using more efficient room heaters, cars that have greater miles-per-gallon ratings, energy efficient compact fluorescent lights, energy efficient appliances, etc. Since energy in an isolated system is not destroyed or created, one might wonder why we need to be concerned about our energy resources, since energy is a conserved quantity. The problem is that the final result of most energy transformations is waste heat transfer to the environment and conversion to energy forms no longer useful for doing work. To state it in another way, the potential for energy to produce useful work has been "degraded" in the energy transformation.

A rational energy policy should encourage research by private industry and should provide funding for basic research, ensure fair access to alternative energy sources, encourage the internalization of external cost of fossil fuel energy, and promote the dissemination of information about the costs and benefits of alternative energy sources.

Questions:

1. Describe three major environmental challenges for fossil fuels in general or one in particular.
2. Rate the following electricity sources for their contribution to climate change from most to least: biomass, coal, solar, wind, nuclear, natural gas, oil, geothermal, hydroelectric, MSW. Is there any compelling reason not to use any of the carbon neutral (no net carbon emissions) sources?
3. Describe the environmental and social concerns associated with biofuels.

In class activities: Design a sustainable city of the future

Websites for more information and further discussion

News: algae car: http://inhabitat.com/first-algae-powered-car-attempts-to-cross-us-on-25-gallons/

For a video presentation on the different ways to use geothermal energy, visit http://geothermal.marin.org/video/vid_pt5.html

Are Electric Vehicles Better for the Environment than Gas-Powered Ones? http://www.technologyreview.com/view/517146/are-electric-vehicles-better-for-the-environment-than-gas-powered-ones/

See excel file with terminology introduced in this chapter.

Chapter 6: Air pollution



Emissions from this power plant in New Mexico contained excessive amounts of sulfur dioxide. Image from National Parks Service (Public Domain).

Learning Objectives:

By the end of this chapter, students will be able to

- Describe the composition and structure of the atmosphere.
- Explain the importance of the ozone layer, its depletion, and specific steps taken to address it.
- Distinguish between indoor and outdoor air pollution and how these compare among industrialized and less industrialized countries
- Identify natural and anthropogenic sources of air pollution
- Explain the effects of air pollution on human and ecosystem health
- Explain how the Clean Air Act legislation works and describe its outcomes

Chapter Outline

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6.1 Composition and Structure of the Atmosphere

Atmosphere refers to the layer of gases that surrounds Earth and is held in place by Earth's gravitational attraction (gravity). The mix of gases in the atmosphere forms a complex system organized into layers that together support life on Earth. Although there are numerous gases, as shown in Table 6.1, the top four gases make up 99.998 % of the volume of *clean dry air* (unpolluted air that does not contain water vapor). Of this dry composition of the atmosphere **nitrogen**, by far, is the most common (78%). Nitrogen dilutes oxygen and prevents rapid or instantaneous burning at the Earth's surface, as oxygen gas is a necessary reactant of the combustion process. Nitrogen is also needed and used by living things to make proteins, though as nitrogen gas, N_2, it is unavailable to most living things. **Oxygen** is used by all living things to make molecules that are essential for life. It is also essential for aerobic respiration as well as combustion or burning. **Argon** is a non-reactive gas and we use it in light bulbs, in double-pane windows, and to preserve priceless documents such as the original Declaration of Independence and the Constitution. **Carbon dioxide** is an essential gas used by plants and other organisms to make sugar (food) through photosynthesis. This process is essential for other life as well because during photosynthesis, water molecules are split apart and their oxygen is released back to the atmosphere. Carbon dioxide also acts as a blanket that prevents the escape of heat into outer space (see more on this in Chapter 7). The atmosphere is rarely, if ever, completely dry. **Water vapor** (water in a 'gas' state) is usually present up to about 4% of the total volume depending on location. In the Earth's desert regions (30° N/S) when dry winds are blowing, the water vapor contribution to the composition of the atmosphere will be near zero.

Table 6.1: Average composition of clean dry air in the lower atmosphere

Gas	Symbol	Content	
Nitrogen	N_2	78.08%	99.998%
Oxygen	O_2	20.95%	
Argon	Ar	0.93%	
Carbon dioxide	CO_2	0.03%	
Neon	Ne	18.20 parts per million	
Helium	He	5.20 parts per million	
Krypton	Kr	1.10 parts per million	
Sulfur dioxide	SO_2	1.00 parts per million	
Methane	CH_4	2.00 parts per million	
Hydrogen	H_2	0.50 parts per million	
Nitrous oxide	N_2O	0.50 parts per million	
Xenon	Xe	0.09 parts per million	
Ozone	O_3	0.07 parts per million	
Nitrogen dioxide	NO_2	0.02 parts per million	
Iodine	I_2	0.01 parts per million	
Carbon monoxide	CO	Trace	
Ammonia	NH_3	Trace	

Source: National Weather Service http://www.srh.noaa.gov/jetstream/atmos/atmos_intro.htm

Earth's atmosphere is divided into four distinct layers based on thermal characteristics (temperature changes), chemical composition, movement, and density (Figure 6.1). The **troposphere** is the lowest layer extending from the surface up to roughly 18 km above the surface depending on location (varies from as low

as 6 km to as high as 20 km). There is continuous flow and swirling of air constantly through convection currents redistributing heat and moisture around the globe. This results in the short-lived and local patterns of temperature and moisture that we call **weather**. Because gravity holds most air molecules close to the Earth's surface, the troposphere is the densest of all layers, containing about 75% of the total mass of the atmosphere. The density of the gases in this layer decrease with height so the air becomes thinner. In response, the temperature in the troposphere also decreases with height. As one climbs higher, the temperature drops from an average around 17°C (62°F) at sea level to about -51°C (-60°F) at the **tropopause,** a sharp boundary at the top of the troposphere that limits mixing between the troposphere and the upper layers.

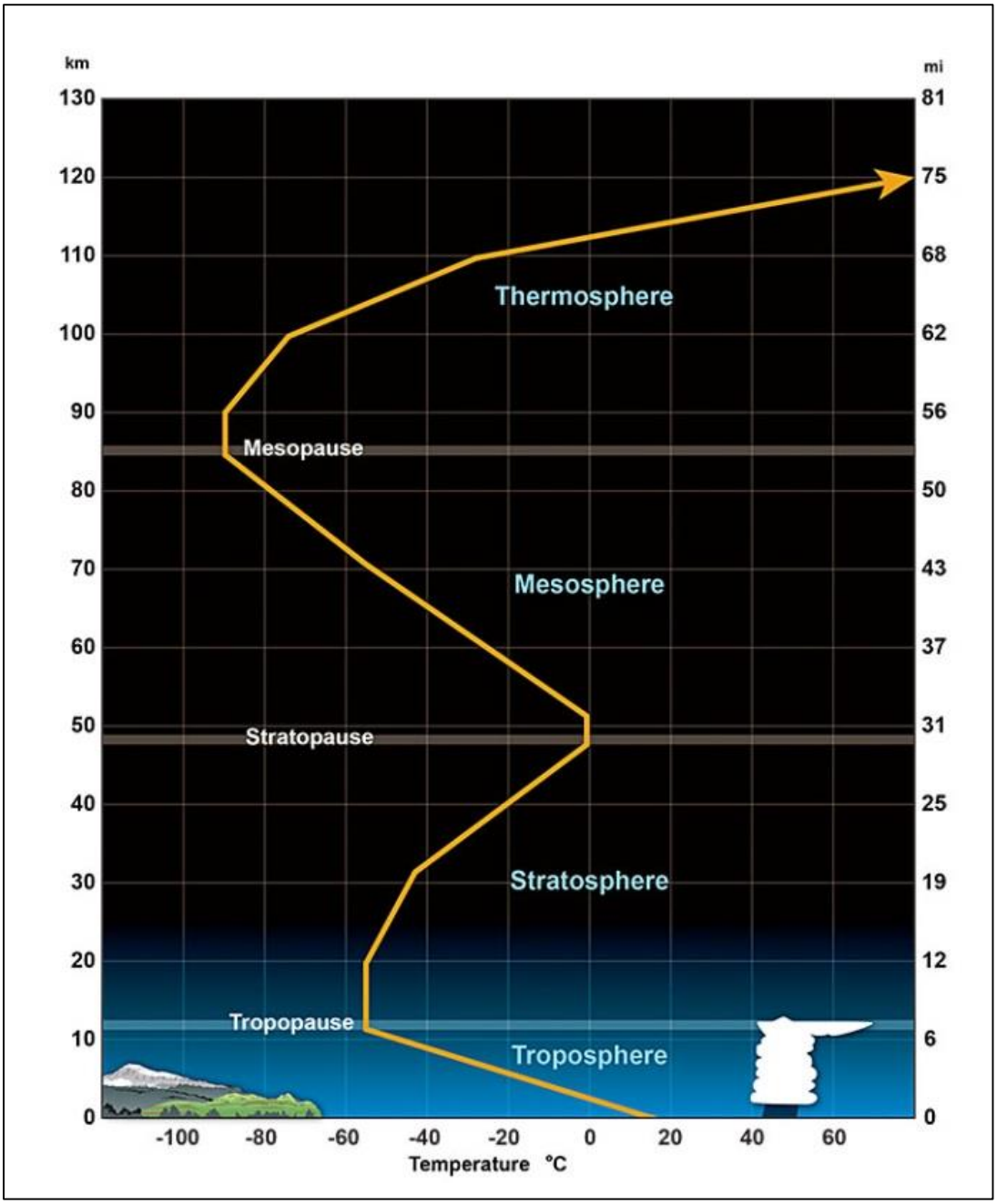


Figure 6.1: An average temperature profile through the lower layers of the atmosphere. Height (in miles and kilometers) is indicated along each side. **Source:** National Weather Service
http://www.srh.noaa.gov/jetstream/atmos/atmprofile.htm

The **stratosphere** is the layer that extends from the tropopause up to about 50 km to 53 km above the Earth's surface depending on location. The proportions of most gases in this layer is similar to that of the troposphere with two main exceptions: 1) there is almost no water vapor in the stratosphere and 2) the stratosphere has nearly 1,000 times more ozone (O_3) than the troposphere. With only about 19% of the total mass of the atmosphere, the density of the stratosphere is significantly lower than the troposphere. However, temperature in this region increases with height as a result of heat that is produced during the formation of ozone (more on ozone in section 6.2). This heat is responsible for temperature increases from an average -51 °C (-60°F) at tropopause to a maximum of about -15°C (5°F) at the top of the stratosphere. This increase in temperature with height means warmer air is located above cooler air. This prevents "convection" as there is no upward vertical movement of the gases. The consequence of this little to no mixing of gases in the stratosphere makes it relatively calm but also means that once substances such as pollutants enter this zone, they can remain suspended for many years. The top of the stratosphere is bound by a boundary known as the **stratopause**.

Above the stratosphere is the **mesosphere** which extends to about 85 km above the Earth's surface. The mesosphere has no ozone molecules and the other gases such as oxygen and nitrogen continue to become less dense with height. As a result, not much ultraviolet and x-ray radiation from the sun is absorbed by molecules in this layer so temperature decreases with altitude. Both the stratosphere and the mesosphere are considered the middle atmosphere.

Between about 85 km and 600 km lies the **thermosphere**. This layer is known as the upper atmosphere. Unlike the mesosphere, the gases in this layer readily absorb incoming high energy ultraviolet and x-ray radiation from the sun. Because of this absorption, the temperature in the thermosphere increases with height and can reach as high as 2,000°C (3,600°F) near the top depending on solar activity. However, despite the high temperature, this layer of the atmosphere would still feel very cold to our skin due to the very thin atmosphere. The high temperature indicates the amount of energy absorbed by molecules but with so few in this layer, the total number of molecules is not enough to heat our skin. There's no sharp boundary that marks the end of the atmosphere. Pressure and density simply continue to decrease with distance until they become indistinguishable from the near-vacuum of outer space.

6.2 Ozone

Ozone (O_3) is a molecule in which three atoms of oxygen are bonded together. The oxygen gas in the air we breathe has two oxygen atoms bonded together (O_2). Ozone is relatively unstable and releases its third oxygen atom readily so it oxidizes and burns things more readily than oxygen gas. This characteristic makes ozone in the troposphere (ground-level ozone) an air pollutant (see section 6.3) but in the stratosphere, ozone is essential for protecting life on Earth. Ozone in the stratosphere is formed when an oxygen molecule (O_2) is broken apart into two separate oxygen atoms (O) by high-energy ultra violet (UV) solar radiation. Each of the resulting oxygen atoms (O) in turn reacts with an oxygen molecule (O_2) creating ozone (O_3) (Figure 6.2). Once produced, ozone can absorb UV radiation breaking the molecule to regenerate an oxygen molecule and a single oxygen atom. So, while ozone is continually being replenished, it is also continually being destroyed. If the rate of ozone creation is equal to the rate of destruction, the total amount will remain the same. Because there is so much oxygen in our atmosphere, this "ozone-oxygen cycle" is continuously absorbing UV radiation.

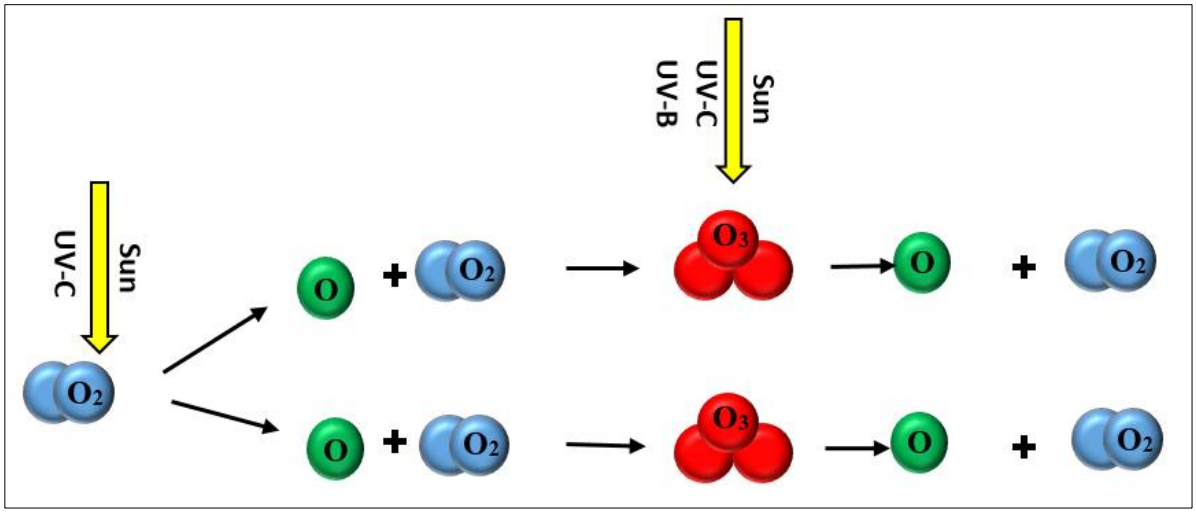


Figure 6.2: The "ozone-oxygen cycle" showing the natural formation and breaking of ozone (O_3) in the stratosphere

6.2.1 The Ozone Layer

Ozone makes up a very small proportion of the gases in our atmosphere and most of it is concentrated in a portion of the stratosphere roughly 17 – 30 km above the surface. This region, called the **ozone layer**, acts as a protective shield that protects life on the surface of the Earth by absorbing most of the harmful portions of the high-energy UV radiation coming from the sun. UV is subdivided into three types namely UV-A, UV-B, and UV-C (Figure 6.3). Of these three types, UV-A is the least energetic and least harmful but can cause some damage to living cells, resulting in sunburns and skin damage. UV-A is also not absorbed by ozone in the stratosphere and is therefore transmitted through the atmosphere to the surface of the Earth. UV-C is the most harmful and most energetic of all UV, but is strongly absorbed in both the thermosphere and the stratosphere and does not make it to the Earth's surface. UV-C is the one responsible for the splitting of oxygen molecules in the stratosphere that leads to the formation of ozone. When ozone absorbs UV it regenerates oxygen atoms and releases heat which warms the upper part of the stratosphere. Since UV-C does not make it to the Earth's surface, the most harmful form of UV radiation that reaches the surface is UV-B. However, the amount of UV-B that reaches Earth's surface is significantly reduced because most of it is absorbed by ozone in the stratosphere. Ozone is the only known gas that absorbs UV-B.

Natural conditions in the stratosphere sustain a dynamic balance between the creation and destruction of ozone which helps to ensure the continued existence of the ozone layer. Any disruption of this balance that results in a higher rate of ozone destruction than ozone creation would result in depletion of ozone. Ozone depletion, consequently, leads to significant increase in the amount of harmful UV-B radiation that reaches the Earth's surface and this what we are talking about when we discuss the **ozone problem**.

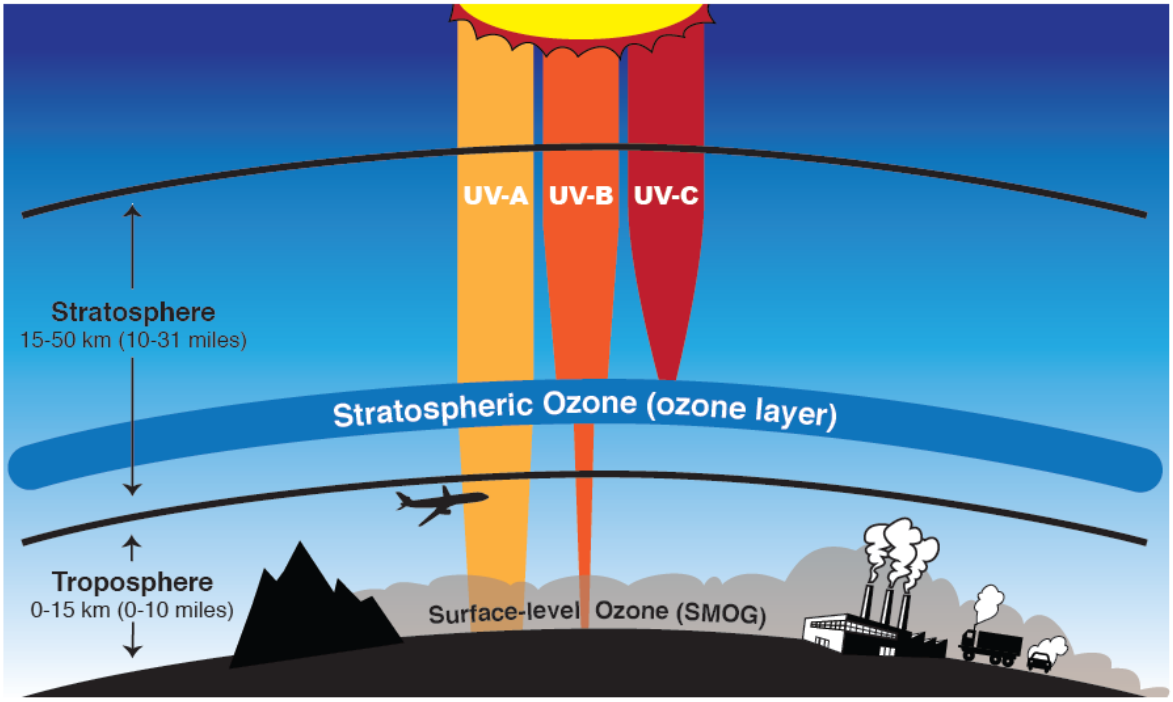


Figure 6.3: Ozone is "good" in the stratosphere because it absorbs most ultraviolet radiation. Ozone is "bad" in the troposphere because it is harmful to breathe and is the primary component of smog in summer. ***Source:*** www.nasa.gov

6.2.2 The Ozone Hole

The **Ozone Hole** is not really a "hole" but rather an area where the thickness of the ozone layer is greatly reduced. This hole is a result of ozone depletion that occurs every year during the Antarctic spring (Figure 6.4) and was first reported to the public by the British Antarctic Survey in 1985. The thickness of the ozone layer above the Antarctic continued to decline while the geographic area covered by the ozone hole continued to increase, reaching its lowest concentration (thickness) in 1994 and largest geographic area in 2000. Recent data shows that ozone concentration globally and in the Arctic and Antarctic is no longer declining.

During the long winter months of darkness over the Antarctic, atmospheric temperatures drop, creating unique conditions for chemical reactions that are not found anywhere else in the atmosphere. During this time, the Antarctic air mass is isolated from the rest of the atmosphere and circulates around the pole in what is known as the *polar vortex*. This isolation allows temperatures to drop low enough to create ice crystals at high altitudes. Ozone, nitric acid, sulfuric acid and other chlorine containing molecules are absorbed on the surfaces of these ice particles. When the sun rises over the Antarctic in the southern spring (October), light rapidly releases free chlorine atoms into the stratosphere. The chlorine atoms react with ozone breaking it down to molecular oxygen and an oxygen atom. The polar vortex keeps the ozone-depleted air inside the vortex from mixing with the undepleted air outside the vortex, hence the formation of an ozone hole.

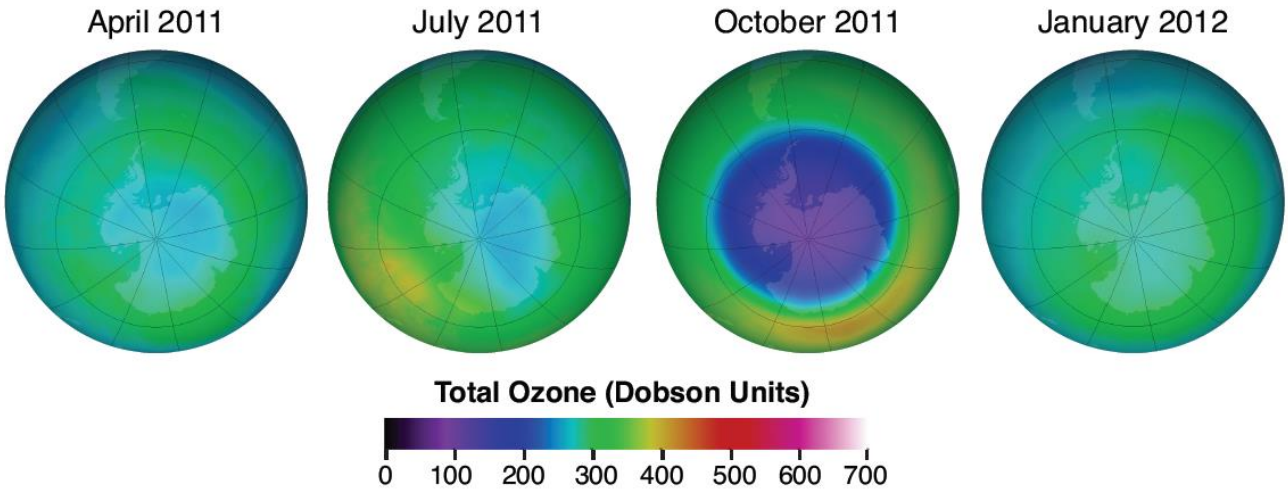


Figure 6.4: Ozone concentrations over the Antarctic region for four months representing the four seasons. Ozone concentration drops significantly during the Antarctic spring (October). ***Source:*** www.nasa.gov

6.2.3 Ozone Depletion

Global ozone concentrations change periodically with regular natural cycles such as changing seasons, winds, and long time scale sun variations. Concentrations of ozone in the atmosphere are measured in parts per billion (ppb). Scientists have been measuring ozone since the 1920's using ground-based instruments that look skyward. Satellite measurements of concentrations of atmospheric ozone began in 1970 and continue today.

Ozone depletion occurs when the rate at which ozone is broken down is greater than the rate of its creation, interfering with the dynamic balance between creation and destruction that maintains the ozone layer. When this happens, the amount of harmful UV-B radiation that reaches the Earth's surface increases. Ozone depletion was first identified over the Antarctic. Scientists suggested that reactions involving man-made chlorine-containing compounds were responsible for depleting ozone in the stratosphere. This hypothesis was based mostly on the physical and chemical properties of these compounds and knowledge about atmospheric conditions.

Chlorofluorocarbons (CFCs) are man-made compounds made up of chlorine, fluorine and carbon. These compounds were commonly used as propellants in everyday products such as shaving cream, hair spray, deodorants, paints and insecticides and as coolants in refrigerators and air conditioners. CFCs are extremely stable molecules and do not react with other chemicals in the lower atmosphere, part of the reason why they were considered a safe choice. Their stability means that they tend to remain in the atmosphere for a very long time. With the constant movement of air in the lower atmosphere, CFCs eventually make their way into the stratosphere. Exposure to ultraviolet radiation in the stratosphere breaks them apart, releasing chlorine atoms. Free chlorine (Cl) atoms then react with ozone molecules, taking one oxygen atom to form chlorine monoxide (ClO) and leaving an oxygen molecule (O_2) (Figure 6.5). The ClO reacts with other atoms freeing up the Cl making it available to react with another ozone molecule, repeating the cycle over and over resulting in ozone depletion.

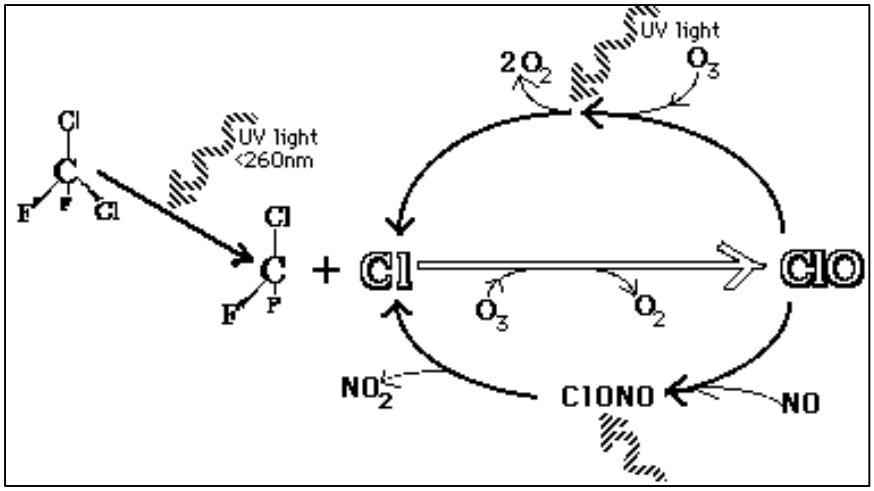


Figure 6.5: Ozone destruction. UV radiation frees a chlorine (Cl) atom from a CFC molecule, this atom reacts with ozone and produces an oxygen gas molecule and chlorine monoxide (ClO). ClO reacts with another oxygen atom, it frees up the Cl atom which then proceeds to destroy another ozone molecule.
Source: Wiki commons https://commons.wikimedia.org/wiki/Category:Ozone#/media/File:Chlorine_catalysis.GIF

If each chlorine atom released from a CFC molecule destroyed only one ozone molecule, CFCs would pose very little threat to the ozone layer. However, when a chlorine monoxide molecule encounters a free atom of oxygen, the oxygen atom breaks up the chlorine monoxide, stealing the oxygen atom and releasing the chlorine atom back into the stratosphere to destroy another ozone molecule. These two reactions happen over and over again, so that a single atom of chlorine, acting as a catalyst, destroys many molecules (about 100,000) of ozone. The consequence of stratospheric ozone depletion is increased levels of UV-B radiation reaching the Earth's surface, posing a threat to human health and the environment. Figure 6.6 shows a lower than average amount of stratospheric ozone over North America in 1997 when it was abnormally cold compared to 1984, which was warmer than average, showing that ozone depletion does not exclusively affect just the South Pole (Antarctic).

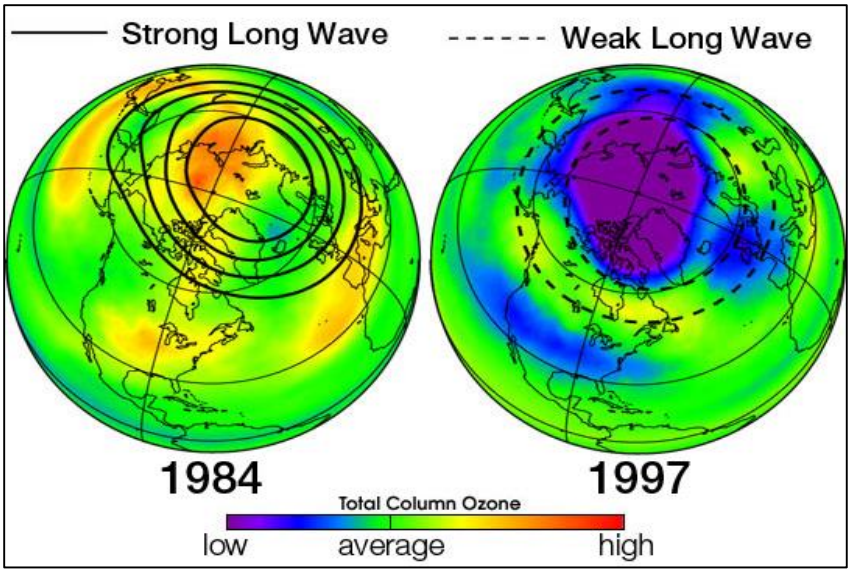


Figure 6.6: Seasonal ozone depletion over North America was lower in 1984 and greater in 1997.
Source: NASA http://earthobservatory.nasa.gov/IOTD/view.php?id=1771

6.2.4 The Montreal Protocol

International policy efforts to restrict production of ozone depleting CFCs culminated in the 1987 treaty known as the **Montreal Protocol** in which signing nations agreed to cut CFC production in half by 1998. At least five follow-up agreements since then helped to deepen the cuts, advanced timetables for compliance, and addressed additional ozone-depleting substances such as halons, methyl chloroform, carbon tetrachloride, and hydrochlorofluorocarbons (HCFCs). Most countries around the world have phased out production of the substances covered by the agreements and industry has been able to shift to safer alternative chemicals. As a result, there's evidence that the Antarctic ozone hole has stopped growing worse, although recovery is not expected anytime soon. Phasing out CFCs and HCFCs is also beneficial in protecting the earth's climate, as these substances are also very damaging greenhouse gases.

As part of the United States' commitment to implementing the Montreal Protocol, the U.S. Congress amended the Clean Air Act (section 6.7), adding provisions for protection of the ozone layer. Most importantly, the amended Act required the gradual end to the production of chemicals that deplete the ozone layer. The Clean Air Act amendments passed by Congress requires the Environmental Protection Agency (EPA) to develop and implement regulations for the responsible management of ozone-depleting substances in the United States. Under the Clean Air Act, EPA has created several regulatory programs to address numerous issues, including:

- ending the production of ozone-depleting substances,
- ensuring that refrigerants and halon fire extinguishing agents are recycled properly,
- identifying safe and effective alternatives to ozone-depleting substances,
- banning the release of ozone-depleting refrigerants during the service, maintenance, and disposal of air conditioners and other refrigeration equipment,
- requiring that manufacturers label products either containing or made with the most harmful ozone depleting substances.

6.3 Outdoor Air Pollution

Air pollution refers to the introduction, into the atmosphere, of substances that have harmful effects on humans, other living organisms, and the environment either as solid particles, liquid droplets or gases. Air pollution can result from natural processes such as dust storms, forest fires, and volcanic eruptions, or from human activities such as biomass burning, vehicular emissions, mining, agriculture, and industrial processes. Improved technology and government policies have helped reduce most types of outdoor air pollution in many industrialized countries including the United States, in recent decades. However, outdoor air quality is still a problem in less industrialized nations, especially in megacities of rapidly industrializing nations such as China and India.

Outdoor pollutants can come from **stationary** (**point**) sources or **mobile** (**nonpoint**) sources (Figure 6.7). Stationary sources have a fixed location, for example power plant smokestacks, burning, construction sites, farmlands and surface mines among others. Mobile sources of air pollutants move from place to place while emitting pollutants. Examples of mobile sources include vehicles, aircrafts, ships, and trains.



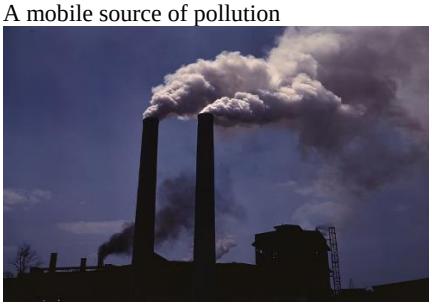
Volcanic eruption, a natural source



Aircraft, a mobile source



A mobile source of pollution



Smokestack, a stationary source

Figure 6.7: Images showing various sources of air pollution, including natural and anthropogenic, stationary and mobile. **Source**: All images obtained from Wiki Commons https://commons.wikimedia.org/wiki/Air_pollution

Pollutants are categorized into two major types based on how they originated namely primary and secondary pollutants. **Primary pollutants** are those released directly from the source into the air in a harmful form. The primary pollutants that account for nearly all air pollution problems are carbon monoxide (58%), volatile organic compounds (VOCs, 11%), nitrogen oxides (15%), sulfur dioxides (13%), and particulate material (3%). **Secondary pollutants** are produced through reactions between primary pollutants and normal atmospheric compounds. For example, ground-level ozone forms over urban areas through reactions, powered by sunlight, between primary pollutants (oxides of nitrogen) and other atmospheric gases such as VOCs.

6.3.1 Criteria pollutants

Under the Clean Air Act (see section 6.7.1), the Environmental Protection Agency (EPA) establishes air quality standards to protect public health and the environment. EPA has set national air quality standards for six common air pollutants namely: 1) carbon monoxide; 2) ground-level ozone; 3) nitrogen dioxide; 4) Sulfur dioxide; 5) lead; and 6) particulate matter (also known as particle pollution). Of the six pollutants, particle pollution and ground-level ozone are the most widespread health threats. EPA calls these pollutants "criteria" air pollutants because it regulates them by developing human health-based and/or environmentally-based criteria (science-based guidelines) for setting permissible levels. The set of limits based on human health is called primary standards. Another set of limits intended to prevent environmental and property damage is called secondary standards.

1. **Carbon Monoxide (CO):** is a colorless, odorless gas emitted from combustion processes, specifically, the incomplete combustion of fuel. Nationally and, particularly in urban areas, the majority of CO emissions to ambient air come from mobile sources. CO can cause harmful health effects by reducing oxygen delivery to the body's organs (like the heart and brain) and tissues. At extremely high levels, CO can cause death.

2. **Ground-level ozone (O_3):** is a colorless gas with a slightly sweet odor that is not emitted directly into the air, but is created by the interaction of sunlight, heat, oxides of nitrogen (NO_x) and volatile organic compounds (VOCs). Ozone is likely to reach unhealthy levels on hot sunny days in urban environments. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of NO_x and VOCs.

3. **Nitrogen dioxide (NO_2)**: is one of a group of highly reactive gasses known as "oxides of nitrogen," or "nitrogen oxides (NO_x)." Other nitrogen oxides include nitrous acid and nitric acid. NO_2 is a yellowish-brown to reddish-brown foul-smelling gas that is a major contributor to smog and acid rain. Nitrogen oxides result when atmospheric nitrogen and oxygen react at the high temperatures created by combustion engines. Most emissions in the U.S. result from combustion in vehicle engines, electrical utility, and industrial combustion.

4. **Sulfur dioxide (SO_2)**: Sulfur dioxide is one of a group of highly reactive gasses known as "oxides of sulfur." The largest sources of SO_2 emissions are from fossil fuel combustion at power plants (73%) and other industrial facilities (20%). Smaller sources of SO_2 emissions include industrial processes such as extracting metals from their ores, and the burning of high sulfur containing fuels by locomotives, large ships, and non-road equipment.

5. **Lead (Pb)**: is a metal found naturally in the environment as well as in manufactured products. The major sources of lead emissions have historically been from fuels in motor vehicles (such as cars and trucks) and industrial sources. As a result of EPA's regulatory efforts to remove lead from gasoline, emissions of lead from the transportation sector dramatically declined by 95 percent between 1980 and 1999, and levels of lead in the air decreased by 94 percent during that time period. The major sources of lead emissions today are ore and metal processing and piston-engine aircraft operating on leaded aviation gasoline. Today, the highest levels of lead in air are usually found near lead smelters.

6. **Particulate material** (PM), sometimes known simply as "**particulates**" refers to solid particles and liquid droplets suspended in the air we breathe. Particulate pollution is made up of a variety of components, including acids (nitrates and sulfates), organic chemicals, metals, soil or dust particles, and allergens (pollen and mold spores). The size of the particles in directly linked to their potential for causing health problems. Particles that are 10 micrometers in diameter or smaller generally pass through the throat and nose and enter the lungs. EPA groups these into two types: "**inhalable coarse particles**," with diameters larger than 2.5 micrometers and smaller than 10 micrometers and "**fine particles**," with diameters that are 2.5 micrometers and smaller. How small is 2.5 micrometers? Think about a single hair from your head. The average human hair is about 70 micrometers in diameter – making it 30 times larger than the largest fine particle (Figure 6.8). Our respiratory systems are equipped to filter larger particles out of the air once it is inhaled. However, the lungs are vulnerable to both coarse particles (PM_{10}), and fine particles ($PM_{2.5}$). These can slip past the respiratory system's natural defenses and get deep into the lungs and some may even get into the bloodstream. Coarse particles come from road dust while fine particles come from combustion processes.

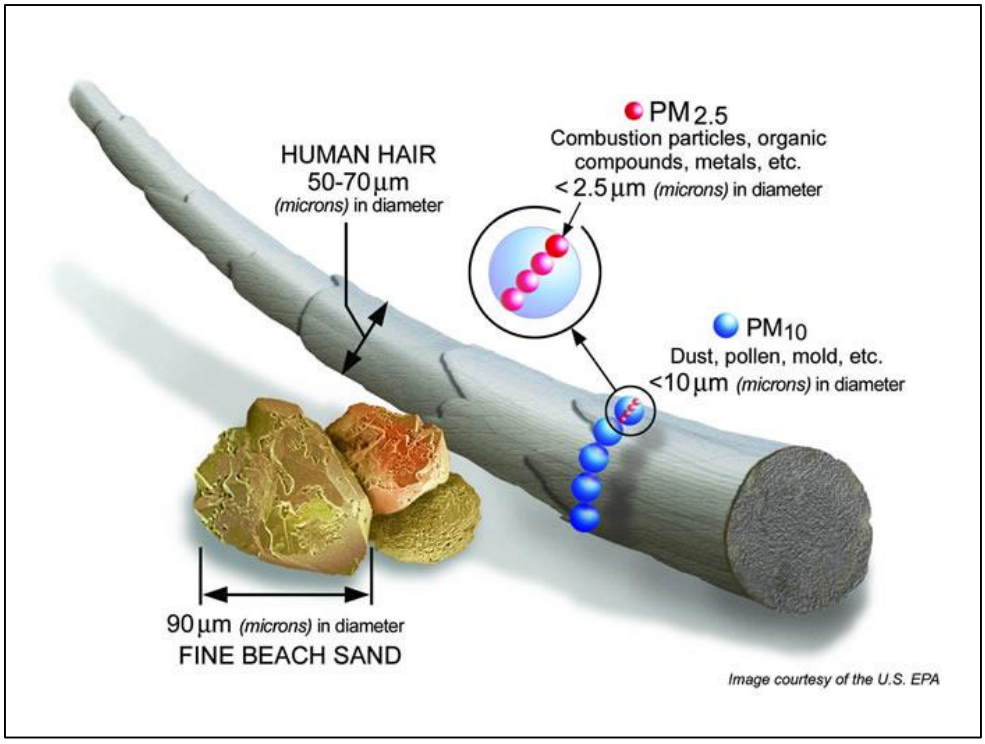


Figure 6.8: Graphic showing size comparison of particulate material (PM_{10} and $PM_{2.5}$) compared to fine beach sand and human hair. **Source**: US EPA http://www.epa.gov/air/particlepollution/basic.html

6.3.2 Volatile Organic Compounds

Volatile organic compounds (VOCs) are carbon-containing chemicals emitted as gases from natural and human-made sources. Natural sources of VOCs include plants, the largest source, and bacteria in the guts of termites and ruminant animals. These compounds are generally oxidized to carbon monoxide and carbon dioxide in the atmosphere. VOCs are of great concern because they are precursors for the formation of ozone, a secondary air pollutant.

A large number of synthetic organic chemicals such as benzene, toluene, formaldehyde, vinyl chloride, chloroform, and phenols are widely used as ingredients in countless household products. Paints, paint strippers, varnishes, many cleaning, disinfecting, cosmetic, degreasing, and hobby products all contain VOCs. Fuels are also made up of organic chemicals. All of these products can release organic compounds while you are using them, and, to some degree, when they are stored. The "new car smell" characteristic of new cars is from a complex mix of dozens of VOC. Also, concentrations of many VOCs are consistently higher indoors (up to ten times higher) than outdoors. They are often held responsible for sick building syndrome, an illness resulting from indoor pollution in which the specific cause is not identified

6.3.3 Smog

Smog is a mixture of air pollutants (sulfur dioxide, nitrogen oxides, ozone, and particulates) that often form over urban areas as a result of fossil fuel combustion. The term was coined from the terms "smoke" and "fog" referring to a brownish haze that pollutes the air, greatly reducing visibility and making it difficult for some people to breathe (Figure 6.9 and 6.10). There are two main types of smog: industrial and photochemical smog. **Industrial smog** is produced primarily by the burning of fossil fuels which produces carbon dioxide (from complete combustion), carbon monoxides (from partial

combustion), sulfur, and mercury. The sulfur reacts with other chemicals in the atmosphere producing several sulfur compounds including sulfur dioxide. These compounds along with particulate material make up industrial smog. **Photochemical smog** is formed when sunlight drives chemical reactions between primary pollutants from automobiles and normal atmospheric compounds. The product is a mix of over 100 different chemicals with the most abundant being ground-level ozone.



Figure 6.9: Smog over Almaty city, Kazakhstan. Photo by Igors Jefimovs. **Source:** Wikicommons https://commons.wikimedia.org/wiki/Category:Smog#/media/File:Smog_over_Almaty.jpg



Figure 6.10: Smog over Santiago in Chile. **Source**: German Wikipedia https://commons.wikimedia.org/wiki/Category:Smog#/media/File:Santiago30std.jpg

6.3.4 Toxic pollutants

Toxic air pollutants, also known as hazardous air pollutants, are those pollutants that are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects. Examples of toxic air pollutants include benzene, which is found in gasoline; perchloroethylene, which is emitted from some dry cleaning facilities; methylene chloride, which is used as a solvent and paint stripper by a number of industries; and others such as dioxin, asbestos, toluene, and metals such as cadmium, mercury, chromium, and lead compounds.

Most air toxics originate from human-made sources, including mobile sources (e.g., cars, trucks, buses) and stationary sources (e.g., factories, refineries, power plants), as well as indoor sources (e.g., some building materials and cleaning solvents). Some air toxics are also released from natural sources such as volcanic eruptions and forest fires. Exposure to air toxics is mainly through breathing but some toxic air pollutants such as mercury can deposit onto soils or surface waters, where they are taken up by plants and ingested by animals and are eventually magnified up through the food chain. Like humans, animals may experience health problems if exposed to sufficiently high quantities of air toxics over time.

6.4 Indoor Air Pollution

In both developed and developing nations, indoor air pollution poses a greater health risk than outdoor air pollution. According to the World Health Organization (WHO) and other agencies such as the Environmental Protection Agency (EPA), indoor air generally contains higher concentrations of toxic pollutants than outdoor air. Additionally, people generally spend more time indoors than outdoors,

hence, the health effects from indoor air pollution in workplaces, schools, and homes are far greater than outdoor. Indoor pollution sources that release gases or particles into the air are the primary cause of indoor air quality problems in homes. Inadequate ventilation can increase indoor pollutant levels by not bringing in enough outdoor air to dilute emissions from indoor sources and by not carrying indoor air pollutants out of the home.

Outdoor air enters and leaves a building by infiltration, natural ventilation, and mechanical ventilation. In infiltration, outdoor air flows into the house through openings, joints, and cracks in walls, floors, and ceilings, and around windows and doors. In natural ventilation, air moves through opened windows and doors. Air movement associated with infiltration and natural ventilation is caused by air temperature differences between indoors and outdoors and by wind. Finally, there are a number of mechanical ventilation devices, from outdoor-vented fans that intermittently remove air from a single room, such as bathrooms and kitchen, to air handling systems that use fans and duct work to continuously remove indoor air and distribute filtered and conditioned outdoor air to strategic points throughout the house. The rate at which outdoor air replaces indoor air is described as the air exchange rate. When there is little infiltration, natural ventilation, or mechanical ventilation, the air exchange rate is low and pollutant levels can increase. High temperature and humidity levels can also increase concentrations of some pollutants.

There are many sources of indoor air pollution in any home (Figure 6.11). These include combustion sources such as oil, gas, kerosene, coal, wood, and tobacco products; building materials and furnishings as diverse as deteriorated, asbestos-containing insulation, wet or damp carpet, and cabinetry or furniture made of certain pressed wood products; products for household cleaning and maintenance, personal care, or hobbies; central heating and cooling systems and humidification devices. Pollutants causing indoor air pollution can also originate from outside sources such as radon, pesticides, and outdoor air pollution. Radon is a naturally occurring radioactive gas produced from the decay of uranium in rock. If a building/home is constructed in an area with uranium containing rock, the gas can seep through the foundations and accumulate in basements. Exposure to radon can cause lung cancer.

The relative importance of any single source depends on how much of a given pollutant it emits and how hazardous those emissions are. In some cases, factors such as how old the source is and whether it is properly maintained are significant. For example, an improperly adjusted gas stove can emit significantly more carbon monoxide than one that is properly adjusted. Some sources, such as building materials, furnishings, and household products like air fresheners, release pollutants more or less continuously. Other sources, related to activities carried out in the home, release pollutants intermittently. These include smoking, the use of unvented or malfunctioning stoves, furnaces, or space heaters, the use of solvents in cleaning and hobby activities, the use of paint strippers in redecorating activities, and the use of cleaning products and pesticides in house-keeping. High pollutant concentrations can remain in the air for long periods after some of these activities.

Risks from indoor air pollution differ between less industrialized and industrialized nations. Indoor pollution has a greater impact in less industrialized nations where many people use cheaper sources of fuel such as wood, charcoal, and crop waste among others for cooking and heating, often with little or no ventilation. The most significant indoor pollutant, therefore, is soot and carbon monoxide. In industrialized nations, the primary indoor air health risks are cigarette smoke and radon.

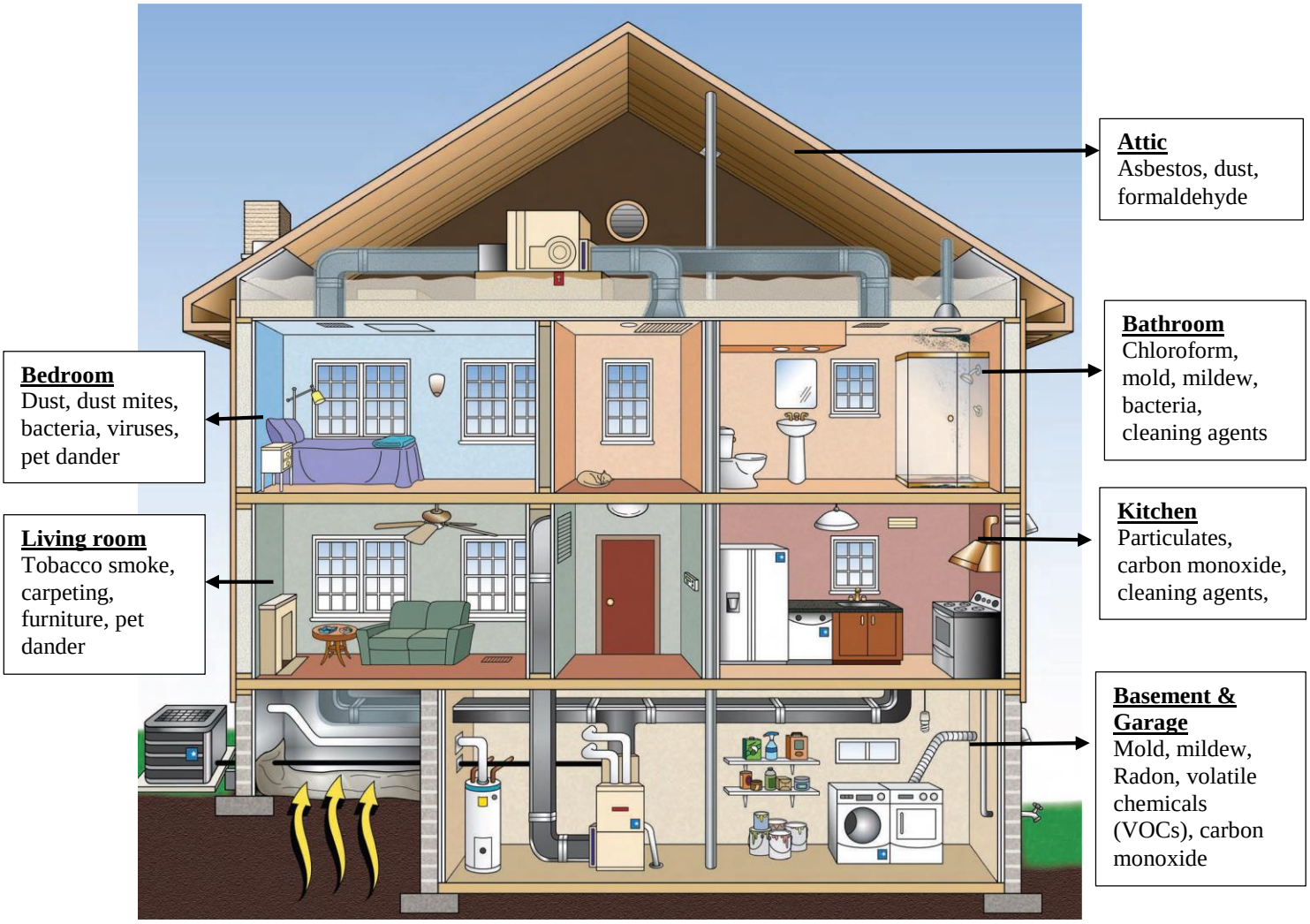


Figure 6.11: Sources of indoor air pollution. **Image source**: EPA http://www.epa.gov/iaq/pdfs/careforyourair.pdf

6.5 Effects of Air Pollution on Human Health

The World Health Organization (WHO) and other international agencies recognize air pollution as a major threat to human health. Numerous scientific studies have linked air pollution to a variety of health problems (Table 6.2) including: aggravation of respiratory and cardiovascular diseases; decreased lung function; increased frequency and severity of respiratory symptoms such as difficulty breathing and coughing; increased susceptibility to respiratory infections; effects on the nervous system, including the brain, such as IQ loss and impacts on learning, memory, and behavior; cancer; and premature death. Immediate effects of air pollution may show up after a single exposure or repeated exposures. Other health effects may show up either years after exposure has occurred or only after long or repeated periods of exposure.

Immediate effects of air pollution include irritation of the eyes, nose, and throat, headaches, dizziness, and fatigue. Such immediate effects are usually short-term and treatable. Sometimes the treatment is simply eliminating the person's exposure to the source of the pollution, if it can be

identified. Symptoms of some diseases, including asthma, hypersensitivity pneumonitis, and humidifier fever , may also show up soon after exposure to some indoor air pollutants.

Table 6.2: Sources and health effects of criteria pollutants

Pollutant	Sources	Health Effects
Ground-level Ozone (O_3)	Secondary pollutant typically formed by chemical reaction of volatile organic compounds (VOCs) and NO_x in the presence of sunlight.	Decreases lung function and causes respiratory symptoms, such as coughing and shortness of breath; aggravates asthma and other lung diseases leading to increased medication use, hospital admissions, emergency department (ED) visits, and premature mortality.
Particulate Matter (PM)	Emitted or formed through chemical reactions; fuel combustion (e.g., burning coal, wood, diesel); industrial processes; agriculture (plowing, field burning); and unpaved roads.	Short-term exposures can aggravate heart or lung diseases leading to respiratory symptoms, increased medication use, hospital admissions, ED visits, and premature mortality; long-term exposures can lead to the development of heart or lung disease and premature mortality.
Lead	Smelters (metal refineries) and other metal industries; combustion of leaded gasoline in piston engine aircraft; waste incinerators; and battery manufacturing.	Damages the developing nervous system, resulting in IQ loss and impacts on learning, memory, and behavior in children. Cardiovascular and renal effects in adults and early effects related to anemia.
Oxides of Nitrogen (NO_x)	Fuel combustion (e.g., electric utilities, industrial boilers, and vehicles) and wood burning.	Aggravate lung diseases leading to respiratory symptoms, hospital admissions, and ED visits; increased susceptibility to respiratory infection.
Carbon Monoxide (CO)	Fuel combustion (especially vehicles), industrial processes, fires, waste combustion, and residential wood burning.	Reduces the amount of oxygen reaching the body's organs and tissues; aggravates heart disease, resulting in chest pain and other symptoms leading to hospital admissions and ED visits.
Sulfur Dioxide (SO_2)	Fuel combustion (especially high-sulfur coal); electric utilities and industrial processes; and natural sources such as volcanoes.	Aggravates asthma and increased respiratory symptoms. Contributes to particle formation with associated health effects.

Source: www.epa.gov

The likelihood of immediate reactions to air pollutants depends on several factors. Age and preexisting medical conditions are two important influences. Some sensitive individuals appear to be at greater risk for air pollution-related health effects, for example, those with pre-existing heart and lung diseases (e.g., heart failure/ischemic heart disease, asthma, emphysema, and chronic bronchitis), diabetics, older adults, and children. In other cases, whether a person reacts to a pollutant depends on individual sensitivity, which varies tremendously from person to person. Some people can become sensitized to biological pollutants after repeated exposures, and it appears that some people can become sensitized to chemical pollutants as well.

6.6 Acid Rain

Pure rainfall is slightly acidic, pH 5.6, because water reacts with atmospheric carbon dioxide to produce weak carbonic acid. When higher than normal amounts of nitric and sulfuric acid occur in the atmosphere, the result is precipitation with a pH below 5.6 which is referred to as **acid rain**. Acid rain includes both wet deposition (rainfall, snow, fog) and dry deposition (particulates). Acid rain formation result from both natural sources, such as volcanoes and decaying vegetation, and man-made sources, primarily emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) resulting from fossil fuel combustion. In the United States, roughly $^2/_3$ of all SO_2 and ¼ of all NO_x come from electric power generation that relies on burning fossil fuels, like coal. Acid rain occurs when these gases react in the atmosphere with water, oxygen, and other chemicals to form various acidic compounds (Figure 6.12). The result is a mild solution of sulfuric acid and nitric acid. When sulfur dioxide and nitrogen oxides are released from power plants and other sources, prevailing winds blow these compounds across state and national borders, sometimes over hundreds of miles. Regions of greatest acidification tend to be downwind from heavily industrialized source areas of pollution.

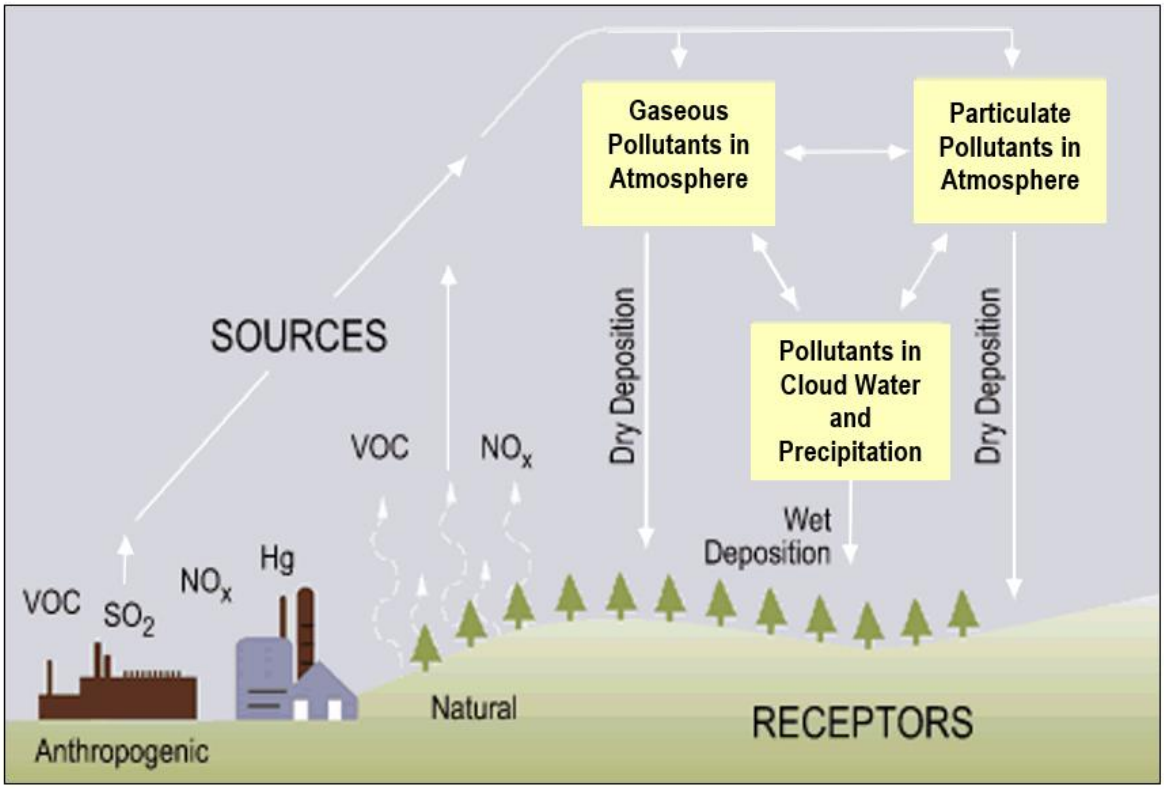


Figure 6.12: Formation of acid rain from both natural and anthropogenic pollutants
Source: US EPA http://www.epa.gov/acidrain/images/origins.gif

Acid rain is a serious environmental problem that is particularly damaging to lakes, streams, and forests and the plants and animals that live in these ecosystems, as well as to infrastructure. Some of the impacts include:

- Leaching of soil nutrients such as calcium, magnesium, and potassium out of the topsoil, altering soil chemistry and harming plants and soil organisms.
- Acid rain causes the release of substances that are toxic to trees and other plants, such as aluminum, into the soil. Scientists hypothesize that this combination of loss of soil nutrients and increase of

toxic aluminum may be one way that acid rain harms trees (Figure 6.13). Such substances also wash away in the runoff and are carried into streams, rivers, and lakes.

- Damage to automotive paints and other coatings. The reported damage typically occurs on horizontal surfaces and appears as irregularly shaped, permanently etched areas.
- Acidic particles contribute to the corrosion of metals (such as bronze) and the deterioration of paint and stone (such as marble and limestone). These effects significantly reduce the societal value of buildings, bridges, cultural objects (such as statues, monuments, and tombstones) (Figure 6.14).
- Sulfates and nitrates that form in the atmosphere contribute to visibility impairment, meaning we cannot see as far or as clearly through the air. Sulfate particles account for 50 to 70 percent of the visibility reduction in the eastern part of the U.S., affecting our enjoyment of national parks, such as the Shenandoah and the Great Smoky Mountains



Figure 6.13: Effects of acid rain on trees, Jizera Mountains, Czech Republic. Image from Wikimedia commons, Public Domain. https://commons.wikimedia.org/wiki/Category:Acid_rain#/media/File:Acid_rain_woods1.JPG

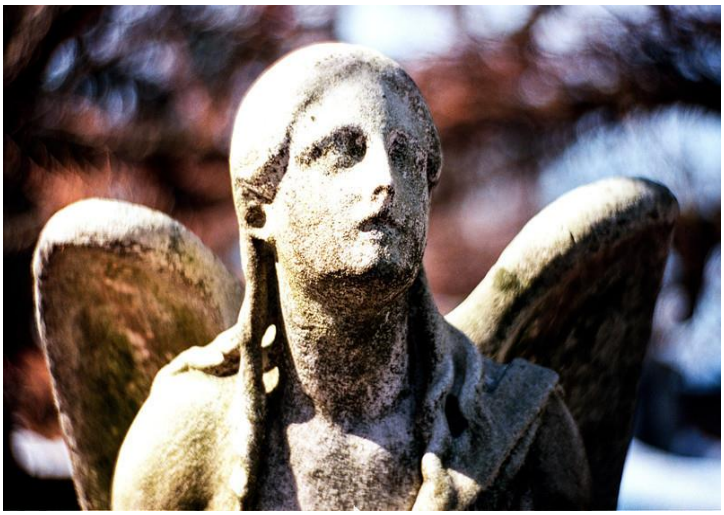


Figure 6.14: Effects of acid rain on a monument in Greenwood cemetery, Brooklyn New York. Photo by James P. Fischer. https://commons.wikimedia.org/wiki/Category:Acid_rain#/media/File:Charlotte_Canda_Memorial_(Angel).jpg

6.7 Air Pollution Legislation

In 1930, 63 people died and 1000 were sickened in Belgium when a phenomenon referred to as temperature inversion caused pollutants to be trapped near the surface, leading to a sudden spike in atmospheric sulfur levels. In October 1948, a thick cloud of air pollution formed above the industrial town of Donora, Pennsylvania. The cloud which lingered for five days, killed 20 people and caused sickness in 6,000 of the town's 14,000 people. In 1952, the infamous London fog in which acid aerosols trapped in the lower atmosphere killed 4000 people. Events like these alerted us to the dangers that air pollution poses to public health.

6.7.1 Clean Air Act

In the United States, several federal and state laws were passed, including the original Clean Air Act of 1963, which established funding for the study and cleanup of air pollution. But there was no comprehensive federal response to address air pollution until Congress passed a much stronger **Clean Air Act in 1970**. That same year Congress created the Environmental Protection Agency (EPA) and

gave it the primary role in carrying out the law. Since 1970, EPA has been responsible for a variety of Clean Air Act programs to reduce air pollution nationwide. The Clean Air Act is a federal law covering the entire country. However, states, tribes and local governments do a lot of the work to meet the Act's requirements. For example, representatives from these agencies work with companies to reduce air pollution. They also review and approve permit applications for industries or chemical processes.

6.7.2 EPA's Role

EPA's mission is basic health and environmental protection from air pollution for all Americans. To achieve this mission, EPA implements a variety of programs under the Clean Air Act that focus on:

- reducing outdoor, or ambient, concentrations of air pollutants that cause smog, haze, acid rain, and other problems;
- reducing emissions of toxic air pollutants that are known to, or are suspected of, causing cancer or other serious health effects; and
- phasing out production and use of chemicals that destroy stratospheric ozone.

Under the Clean Air Act, EPA sets limits on certain air pollutants, including setting limits on how much can be in the air anywhere in the United States. The Clean Air Act also gives EPA the authority to limit emissions of air pollutants coming from sources like chemical plants, utilities, and steel mills. Individual states or tribes may have stronger air pollution laws, but they may not have weaker pollution limits than those set by EPA. EPA must approve state, tribal, and local agency plans for reducing air pollution. If a plan does not meet the necessary requirements, EPA can issue sanctions against the state and, if necessary, take over enforcing the Clean Air Act in that area. EPA assists state, tribal, and local agencies by providing research, expert studies, engineering designs, and funding to support clean air progress. Since 1970, Congress and the EPA have provided several billion dollars to the states, local agencies, and tribal nations to accomplish this.

6.7.3 State and Local Governments' Role

It makes sense for state and local air pollution agencies to take the lead in carrying out the Clean Air Act. They are able to develop solutions for pollution problems that require special understanding of local industries, geography, housing, and travel patterns, as well as other factors. State, local, and tribal governments also monitor air quality, inspect facilities under their jurisdictions and enforce Clean Air Act regulations. States have to develop State Implementation Plans (SIPs) that outline how each state will control air pollution under the Clean Air Act. A SIP is a collection of the regulations, programs and policies that a state will use to clean up polluted areas. The states must involve the public and industries through hearings and opportunities to comment on the development of each state plan.

6.7.4 Outcomes of the Clean Air Act

For more than forty years, the Clean Air Act has cut pollution as the U.S. economy has grown. The combined emissions of the six criteria pollutants has continued to decrease while population, gross domestic product, energy consumption, and vehicle miles travelled have all continued to increase (Figure 6.14). The following is a summary of some of the accomplishments of the Clean Air Act:

- Clean Air Act programs have lowered levels of the six criteria pollutants - particulates, ozone, lead, carbon monoxide, nitrogen dioxide and sulfur dioxide - as well as numerous toxic pollutants.

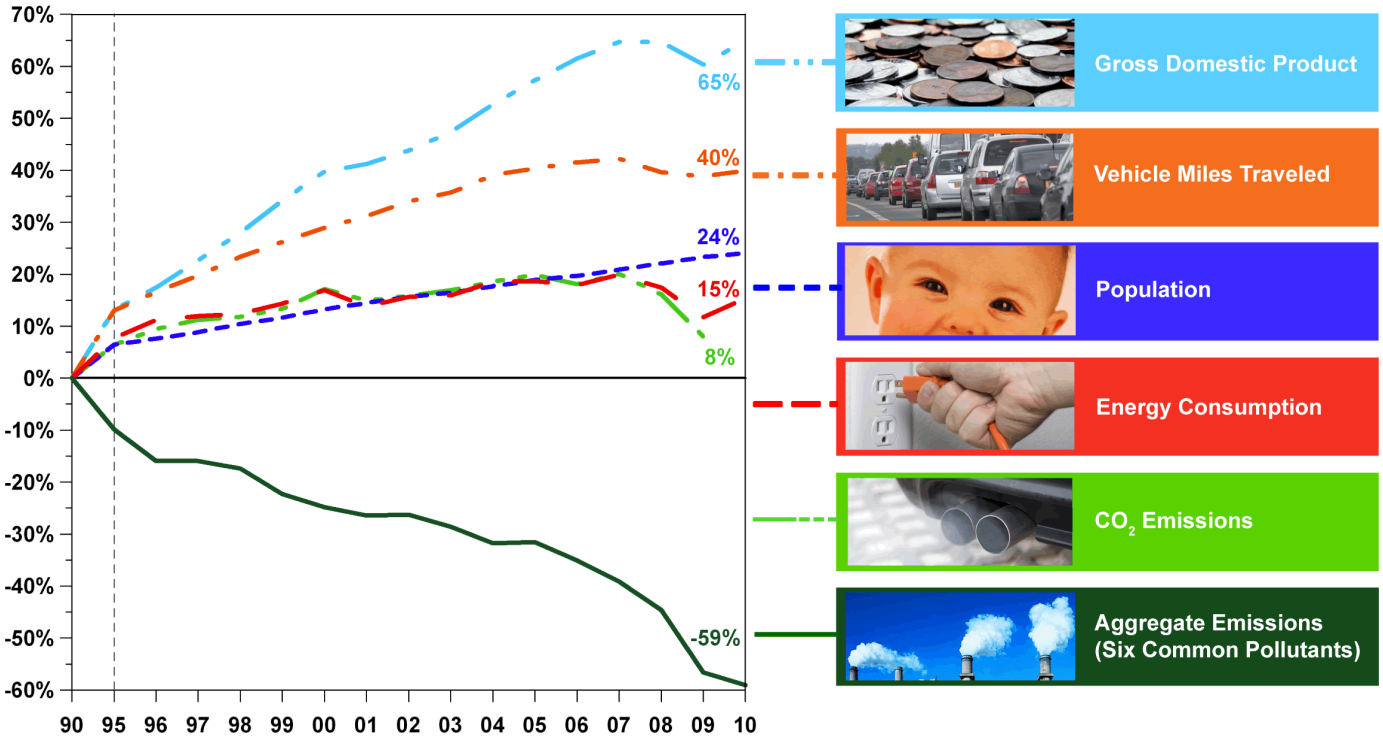


Figure 6.14: Showing a decrease in the combined emissions for the six criterial pollutants in the past two decades. Meanwhile, population, energy consumption, vehicle miles travelled, and gross domestic product have all increased. **Source**: US EPA

- From 1970 to 2012, aggregate national emissions of the six common pollutants alone dropped an average of 72 percent while gross domestic product grew by 219 percent (Figure 6.14). This progress reflects efforts by state, local and tribal governments; EPA; private sector companies; environmental groups and others.
- The emissions reductions have led to dramatic improvements in the quality of the air that we breathe.
- These air quality improvements have enabled many areas of the country to meet national air quality standards set to protect public health and the environment. For example, all of the 41 areas that had unhealthy levels of carbon monoxide in 1991 now have levels that meet the health-based national air quality standard. A key reason is that the motor vehicle fleet is much cleaner because of Clean Air Act emissions standards for new motor vehicles.
- Airborne lead pollution, a widespread health concern before EPA phased out lead in motor vehicle gasoline under Clean Air Act authority, now meets national air quality standards in most areas of the country.

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National Aeronautics and Space Administration (NASA) http://www.nasa.gov/

National Weather Service http://www.srh.noaa.gov/jetstream/atmos/layers.htm

The Carbon Cycle

Carbon, just like all other elements, cycles through the environment and is constantly in the process of changing forms and locations. In this section, as in many other pieces of scientific literature, we will periodically refer to carbon by its chemical symbol, C. There is no new carbon in the world, rather, all carbon is continuously recycled from one form to another. All plants, animals (including humans!), fungi, bacteria, and archaea are made of mostly carbon-based molecules such as lipids, carbohydrates, proteins, and nucleic acids. Carbon is also prevalent in soils, rocks and sediments, water bodies (dissolved), and the atmosphere. These locations where carbon resides are known as pools or **reservoirs**, and the processes that move carbon from one location to another are called **fluxes**. Figure 7.1 shows a simplified version of the global carbon cycle.

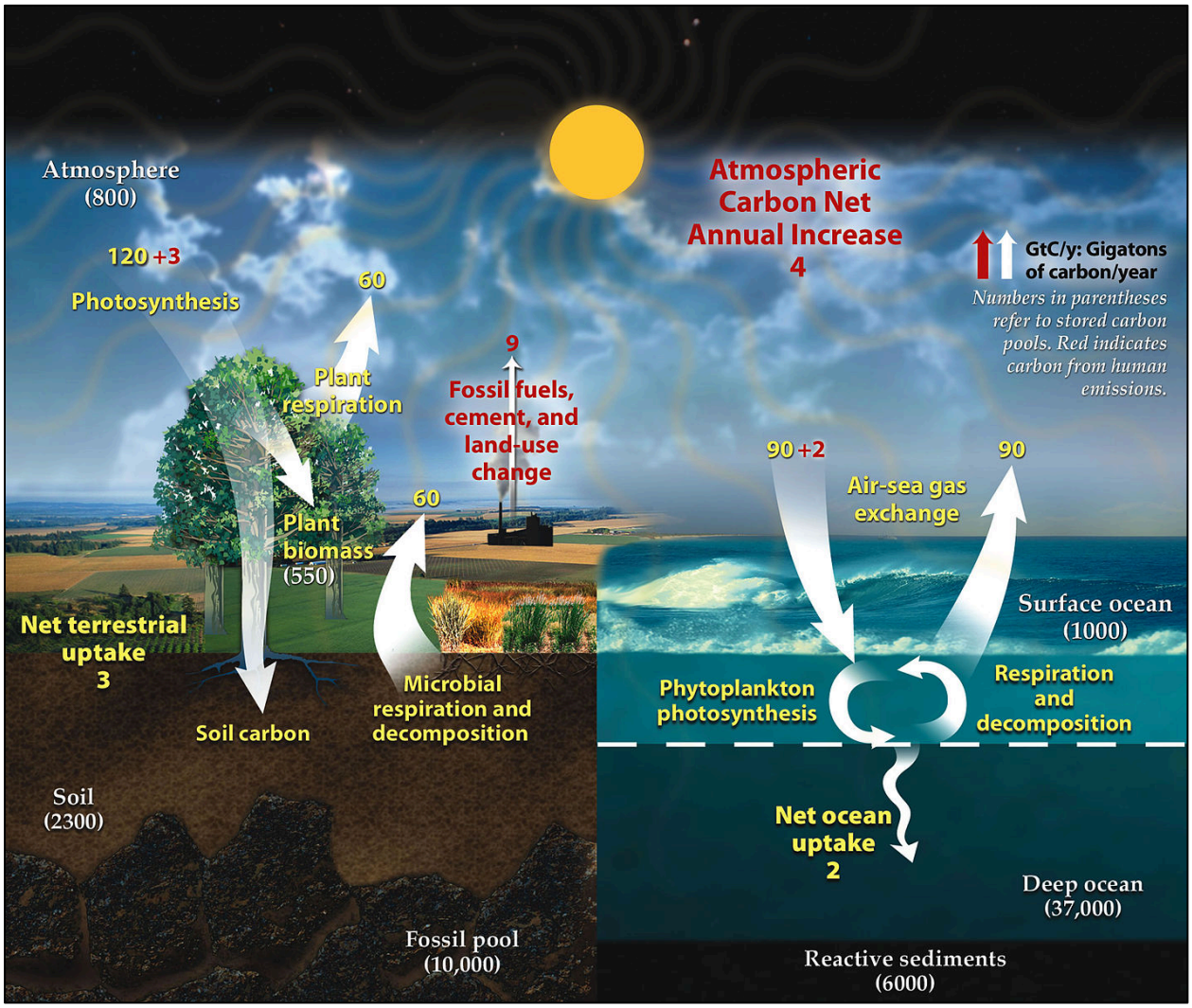


Figure 7.1: A simplified carbon cycle. Diagram adapted from U.S. DOE, Biological and Environmental Research Information System.

Some reservoirs hold on to carbon for only a short time. **Aerobic** (oxygen-using) organisms convert carbohydrates created by other organisms into **carbon dioxide** (CO_2) almost instantaneously, which they exhale into the atmosphere. When considering the flux of respiration, living organisms are the **source** of carbon, and the atmosphere is the **sink**. The carbon stays in the reservoir of living organisms for a relatively short time, depending on their life span, from hours and days to years and decades. In contrast, the **residence time** of carbon in the fossil pool is dramatically different. Fossil fuels form over a course of 300-400 million years, forming from ancient plants and animals that decomposed slowly under very specific, **anaerobic** (without oxygen) conditions in wetland environments. Their bodies were gradually transformed by the heat and pressure of the Earth's crust into the fossil fuels that we mine today to provide petroleum oil, natural gas, and coal (see more on this in chapter 4).

Reservoirs and fluxes of importance

The two largest reservoirs of carbon on Earth are the oceans, which cover the majority of Earth's surface, and the **lithosphere** (the mineral fraction of Earth: soils, rocks, and sediments). Each of these reservoirs holds more carbon than all of the other reservoirs combined. Much of the carbon stored in these reservoirs, especially deep in the lithosphere or in deep ocean environments, has an extremely long residence time, and does not actively participate in rapid fluxes. The notable exceptions here, of course, are fossil fuels, which are mined by humans and converted into gaseous forms of carbon through combustion.

Biomass, which is biological material derived from living, or recently living organisms, is a much smaller reservoir of carbon. The amount of carbon stored in all of the terrestrial vegetation (550 Gt C) (Gt = gigatonne = 10^9 metric tons = 10^{15} g) is just a fraction of that stored in the oceans (38,000 Gt C) and lithosphere (18,000 Gt C). All of the carbon that is currently stored in all of the vegetation on Earth got there through the process of **photosynthesis**. Plants and other photosynthetic organisms are called **primary producers**, because they "fix" atmospheric CO_2 into organic carbon, such as sugar, a form that is usable by animals and other organisms that need to consume their carbon molecules.

Photosynthetic organisms, such as plants, algae, and cyanobacteria, bring in CO_2 from the atmosphere and, using energy from the sun, convert CO_2 and water into glucose molecules (organic carbon). The products of photosynthesis are oxygen and glucose (Equation 7.1). These glucose molecules are simple sugars that **autotrophs** ("self-feeders") can "burn" for energy, or transform into other usable carbon molecules through the process of cellular respiration (described in the next paragraph), or to build plant biomass. Photosynthesis takes place in organelles called **chloroplasts**, shown in Figure 7.2. Photosynthesis accounts for 123 Gt of C per year that is removed from the atmosphere and stored in plant biomass. Such a massive amount of

photosynthesis occurs on Earth that no other single flux moves as much carbon in the same timeframe.

$$6CO_2 + 6H_2O + \text{solar energy} \rightarrow C_6H_{12}O_6 + 6O_2 \qquad \textbf{Eq. 7.1}$$

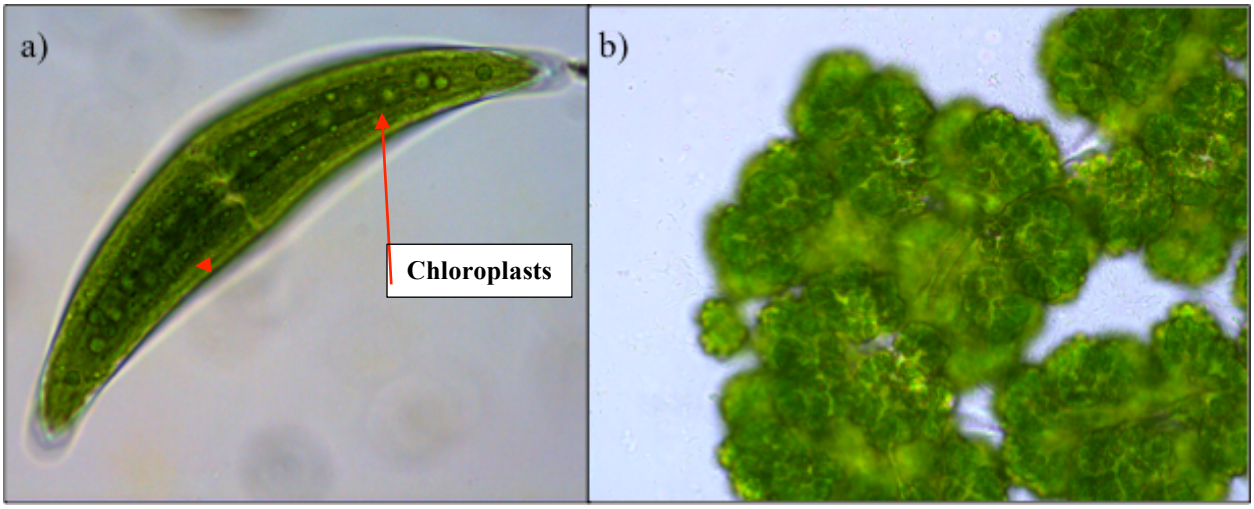


Figure 7.2: Chloroplasts visible in freshwater algae. Chloroplasts are green in color due to the chlorophyll *a* they contain, and are the site of photosynthesis. Chlorophyll *a* is the green pigment that allows plants, algae, and cyanobacteria to absorb the energy they need for photosynthesis from sunlight. a) *Closterium moniliferum* Ralfs, (Chlorophyta) green coccoid algae; b) *Botryococcus braunii* Kützing, (Chlorophyta) green coccoid algae with discoid chloroplasts. Image credit: K. Manoylov, Lake Sinclair, GA

Biomass in the carbon cycle, including plants and animals, is the reservoir of carbon that we are most likely most familiar with, and also the reservoir that is most readily available to us. We all participate in the flux of **consumption** of carbon when we eat food. All of our food is simply plant and/or animal biomass. Our body takes the carbon molecules contained in this biomass, and uses them, along with the oxygen we breathe in, for **cellular respiration** to create the adenosine triphosphate (ATP) we need for energy. The products of cellular respiration include the CO_2 we exhale, water, and energy that is stored in ATP (Equation 7.2). Our bodies also builds additional biomass out of the carbon molecules in this food, allowing us to create new cells for growth or replenishment. This is the only way we, and all other **heterotrophs** ("other-eaters"), can bring in the carbon we need to build and maintain our bodies. Remember, you are what you eat!

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy} \qquad \textbf{Eq. 7.2}$$

Cellular respiration is an important flux in the carbon cycle, and one that contributes carbon to the atmosphere. Remember that animals and other heterotrophs complete cellular respiration using the carbon molecules that they bring in through their food. Plants and other photosynthetic autotrophs complete cellular respiration using the carbon molecules they formed from CO_2 through photosynthesis. Any carbon molecules that are left over after the organism has acquired sufficient energy through cellular respiration make up the biomass of the plant. As plants and animals die and decompose, their bodies are consumed by decomposer organisms such as fungi and bacteria. Through the flux of **decomposition**, some decaying biomass is converted into atmospheric carbon by the decomposers, while most of the biomass is buried into the soil, contributing to soil carbon. In oxygen-rich environments, decomposers rapidly consume dead and decaying biomass using the same process of aerobic cellular respiration described above. In oxygen-deficient environments, decomposers complete other metabolic pathways, and very slowly consume the organic matter. Some of the gases produced from anaerobic decomposition include **methane** (CH_4), **nitrous oxide** (N_2O), and the foul-smelling hydrogen sulfide (H_2S).

The biomass reservoir of the carbon cycle is also important to us as a source of energy. Through the flux of **combustion**, we convert the **potential energy** held in biomass into heat energy that we can use, and release carbon dioxide in the process. If you have ever burned logs on a campfire, or even burned food on the stove, you have completed this flux of biomass combustion. Of course, this happens naturally as well, the best example being natural forest fires caused by lightning strikes. The chemical reaction for combustion is identical to the chemical reaction for cellular respiration. The difference is that in cellular respiration, energy is released in a controlled fashion, and captured in ATP molecules. In combustion, all of this energy is released rapidly in the form of light and heat.

As all of the fluxes we've discussed so far involve the atmosphere, we have not yet discussed the flux that connects the atmosphere to the oceans. Carbon can enter the oceans through two primary fluxes: first through photosynthesis by algae or cyanobacteria (also called phytoplankton in Figure 7.1), and second through the chemical reaction of **ocean-atmosphere exchange**. The ocean, as with all surface water bodies, always contains some dissolved CO_2. This CO_2 is in **equilibrium** with the CO_2 in the air. Some atmospheric CO_2 is constantly dissolving into the ocean, while some dissolved CO_2 is constantly diffusing into the atmosphere. Under normal conditions, these two fluxes will be happening at equal rates. As you can see in Figure 7.1, however, this is no longer the case. In the section *Human impacts on the carbon cycle*, we will discuss why this is the case.

Activity: Better understanding the carbon cycle

To further review the carbon cycle, and better understand the human impacts on it, use this interactive graphic from Woods Hole laboratories: http://www.whoi.edu/feature/carboncycle/. As you will see, the information described in this text is only a small portion of the total carbon

cycle on Earth. Finally, complete Table 7.1 as a way to review the sink/source relationship within this cycle. See if you can correctly identify the source and sink of carbon for each of these important fluxes in the carbon cycle.

Table 7.1. Practice understanding the sink/source relationship with cycles

Carbon flux	Carbon source	Carbon sink
Cellular respiration	Carbohydrates in living organisms	CO_2 in the atmosphere
Photosynthesis		
Consumption		
Combustion		
Decomposition		
Ocean/atmosphere exchange		
Fossil fuel formation		

Human impacts on the carbon cycle

Humans, just like all other living organisms, have impacted the global carbon cycle since the dawn of our species. However, the magnitude of our impacts has changed dramatically throughout history. The **Industrial Revolution**, which occurred around the turn of the 19th century, began to make major changes in the use of resources around the world. Beginning in Britain, industrialization eventually affected the whole world. The development of coal-fueled steam power, and later transportation following the discovery of large oil deposits, had enormous influence on the economic and social structure of the world. As the world accelerated in the production and transportation of manufactured goods, the production and consumption of fossil fuels grew. As economic growth continued to increase, so did the production of carbon dioxide

through fossil fuel combustion. See Figure 7.4 later in this text.

Some of the human impacts on the carbon cycle have been quantified for you in Figure 7.1. Changes to fluxes in the carbon cycle that humans are responsible for include: increased contribution of CO_2 and other **greenhouse gases** to the atmosphere through the combustion of fossil fuels and biomass; increased contribution of CO_2 to the atmosphere due to land-use changes; increased CO_2 dissolving into the ocean through ocean-atmosphere exchange; and increased terrestrial photosynthesis. The first two impacts, both contributing excess CO_2 to the atmosphere at a rate of 4 Gt of carbon per year have, by far, the largest impact on our planet. For this reason, this is the change that we will most often focus on throughout this section. The excess CO_2 in the atmosphere is responsible for the increased CO_2 dissolving into the ocean, which we will discuss later in this section. This is also, in part, responsible for the increased terrestrial photosynthesis that can be observed, as additional CO_2 is available to plants for photosynthesis. However, intensive agricultural and forestry practices also contribute to the change in this flux.

One characteristic example of a human impact on the carbon cycle is illustrated in Figure 7.3. Throughout most of our recent human history, people have been physically altering the landscape around them in order to have more control over their surroundings and increase their odds of survival. One way that people have done this is through agriculture. In order for most forms of agriculture to be successful, native vegetation is eliminated or minimized. Resources from this native vegetation, such as wood, may be used for combustion to provide heat, sanitation, or fuel for cooking. Combustion may also be used as an efficient way to clear the land and make way for crops or grazing lands for livestock. Often, settlements are formed around these newly fashioned agricultural fields, and the land is used in a similar fashion for many years in the future.

Let's identify the ways in which humans are impacting the carbon cycle in this scenario of agricultural establishment. You should be able to identify from the above paragraph that the flux of combustion will release CO_2 previously held in vegetation into the atmosphere. In addition, remember that the land that used to house native vegetation is now home to agricultural lands. In most controlled agricultural environments, there is less total vegetative biomass than there would be under natural conditions. This decreased biomass leads to lower total photosynthesis rates, thereby decreasing the amount of CO_2 that is removed from the atmosphere and turned into plant biomass. Also, open soil on the fields between crops, during the winter months, or as a result of overgrazing allows for the air to penetrate deep into the soil structure. This provides the environment necessary for enhanced aerobic respiration by soil microorganisms. This decreases soil carbon, which can lead to erosion and soil degradation, and also releases additional CO_2 to the atmosphere.

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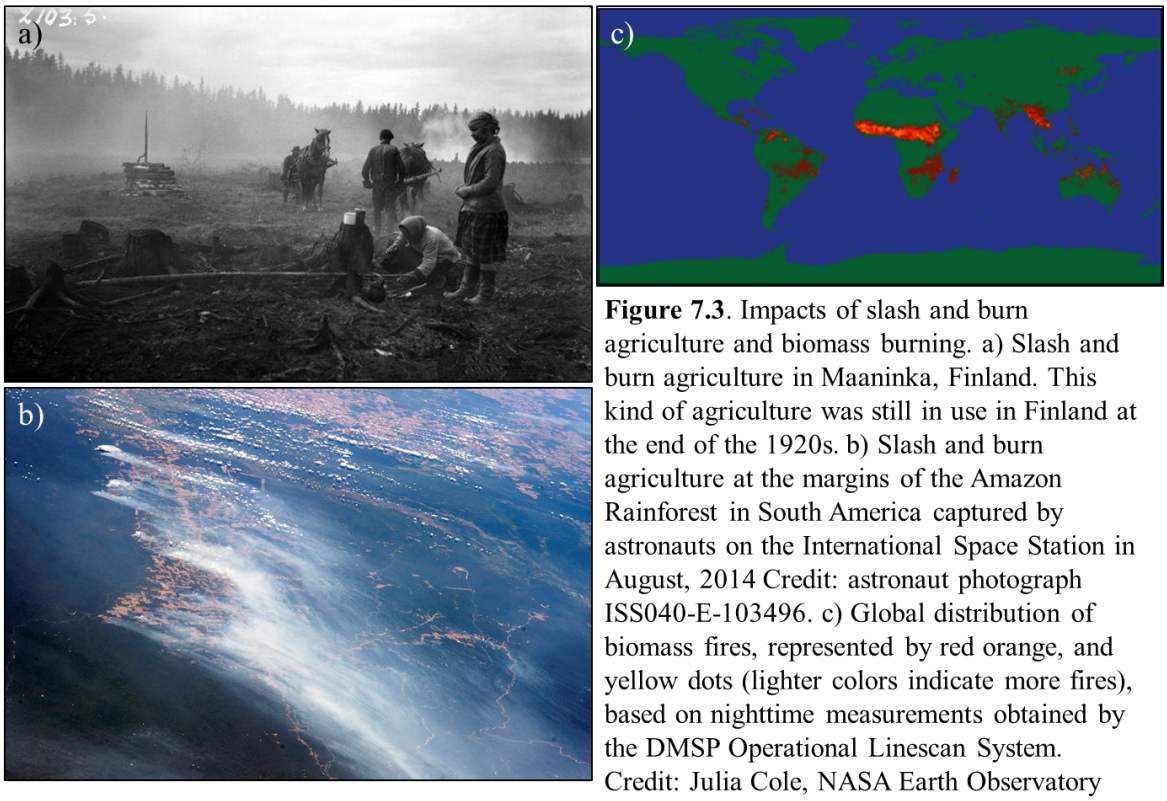


Figure 7.3. Impacts of slash and burn agriculture and biomass burning. a) Slash and burn agriculture in Maaninka, Finland. This kind of agriculture was still in use in Finland at the end of the 1920s. b) Slash and burn agriculture at the margins of the Amazon Rainforest in South America captured by astronauts on the International Space Station in August, 2014 Credit: astronaut photograph ISS040-E-103496. c) Global distribution of biomass fires, represented by red orange, and yellow dots (lighter colors indicate more fires), based on nighttime measurements obtained by the DMSP Operational Linescan System. Credit: Julia Cole, NASA Earth Observatory

As you learned in Chapter 5, biomass is an important form of energy to human civilization. Prior to the Industrial Revolution, this was essentially the only form of fuel to which most people on Earth had access. In many **less-industrialized countries**, combustion of biomass such as wood or animal dung is still the primary energy source that many citizens, particularly in rural areas, depend on for domestic use (heating, sanitation, and cooking) as it is inexpensive, relatively efficient, and readily available. Figure 7.3c shows the global distribution of biomass fires in the world. While the burning of biomass for domestic use contributes to some of these fires, it is the so-called **slash-and-burn agriculture** that makes up a larger contribution. Take a minute to compare the areas highlighted in Figure 7.3c to the countries of the world that are currently experiencing rapid population growth (Chapter 3). If you need a refresher, use the CIA World Factbook website to view current global population growth values by country: https://www.cia.gov/library/publications/the-world-factbook/rankorder/2002rank.html.

While biomass burning still has a significant impact on the global carbon cycle, human impacts on fluxes such as fossil fuel extraction and combustion continue to grow. For a review of the impacts of non-renewable energy sources such as fossil fuels, see Chapter 4. Burning of any fossil fuel (coal, natural gas, crude oil) moves carbon from a previously-sequestered state deep within the Earth's crust into carbon dioxide in the atmosphere. As countries become more industrialized, their reliance on and combustion of fossil fuels tends to increase. Look at the graph in Figure 7.4, which compares CO_2 emissions from fossil fuels of regions across the globe.

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How has the use and distribution of fossil fuels changed throughout the past 250 years?

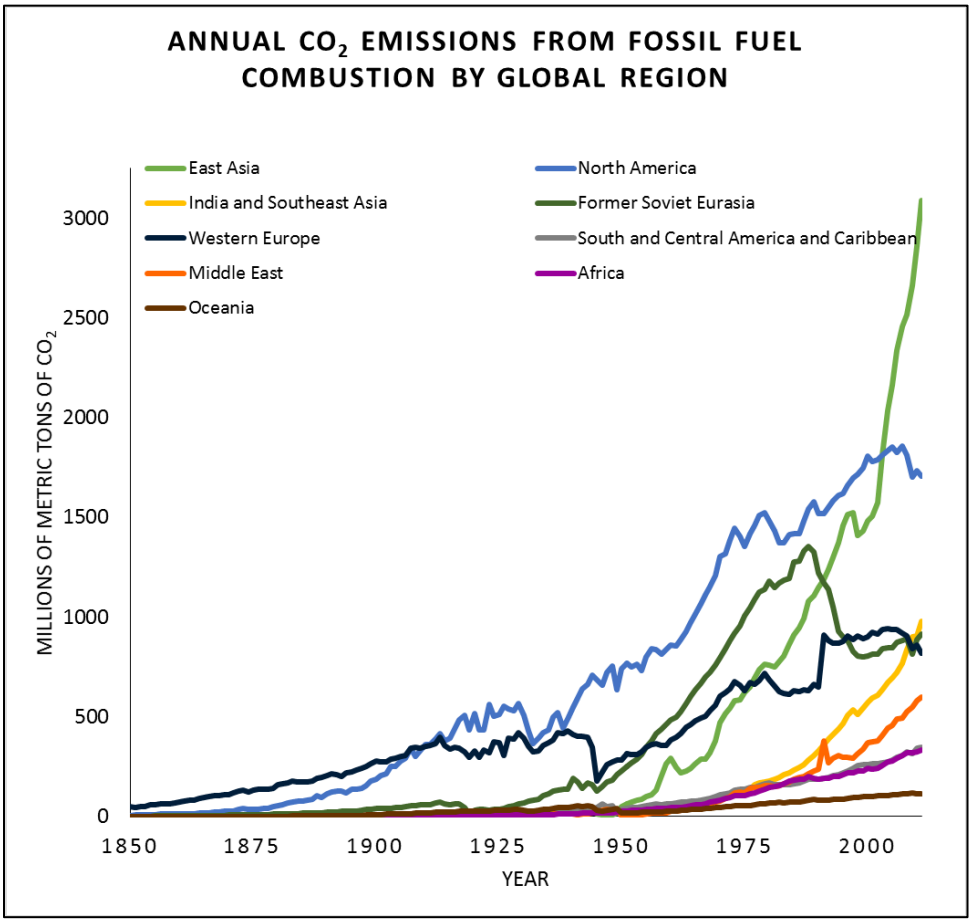


Figure 7.4. Total annual CO_2 emissions from fossil fuel combustion 1850-2011 by global region. Data from the Carbon Dioxide Information Analysis Center (CDIAC) http://cdiac.esd.ornl.gov/

The data shown in Figure 7.4 reveals much about the regions of the world it depicts. The effects of historic events such as the Great Depression of 1929-1939, World Wars, the fall of the Soviet Union in 1991, and the Kuwait oil fires of 1991 can be seen. Furthermore, between 1850 and 2011, different regions have gone in and out of the lead position as top producer of CO_2 from fossil fuel emissions. Population is one reason why fossil fuel use has changed throughout time. This is particularly apparent when comparing the data for Western Europe to that of India and Southeast Asia.

As countries industrialize, their relationship with agriculture also changes. **More-industrialized countries** rely very little on slash-and-burn agriculture. Their agricultural practices, however, are no less impactful on the environment. The growing population (Chapter 3) in many countries has required agriculture to become industrialized in order to meet demand. As a person living in the United States, **industrialized agriculture** probably produces the vast majority of the food you eat, including grains, fruits and vegetables, dairy and eggs, meats, and even fish. Industrialized agriculture can refer to a variety of practices, but has several main components: the use of motorized machinery; the use of chemicals such as fertilizers, pesticides, hormones, and/or antibiotics; and the intense and efficient production of one product across a large area of land.

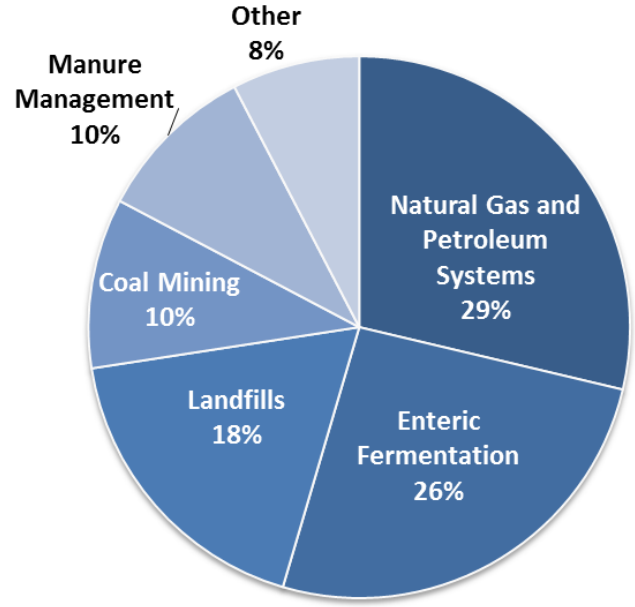


Figure 7.5. US methane emissions by source. 36% of the US methane production comes from agriculture: enteric fermentation (production of methane by anaerobic bacteria within the ruminant gut) and manure management. All emissions estimates from the Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2013. US EPA.

One example of the impacts of industrialized agriculture is the production of methane (CH_4), a potent greenhouse gas. You will learn more about methane later in this section. As you saw earlier, methane is a common product of anaerobic metabolisms. The gut of **ruminant animals** (such as sheep, cattle, and goats) has evolved to allow the animals to digest the very tough carbon molecules, such as cellulose, in grass. They do this through symbiosis, or cooperation, with anaerobic bacteria who live in the gut tract. These anaerobic bacteria produce methane and other gases as a result of their metabolism when they break down molecules like cellulose. This is sometimes called enteric fermentation. The methane gas is excreted from the animal, and this contributes significantly to total methane emissions (Figure 7.5). A similar type of bacteria live in the fecal matter, or manure, of livestock. As the manure is handled or stored for future use, methane is also released to the environment.

The methane excretions of one cow or a few sheep would be miniscule and insignificant. If you were a small farmer with only enough livestock to feed your family, your contribution to total methane emissions would be close to zero. However, the demand for animal protein from meat, dairy, and eggs is very large in the United States. As of January 2015, the United States had a

total cattle inventory of 89.9 million animals, and in 2014, 25.5 billion pounds of beef was consumed in the United States (statistics: National Cattlemen's Beef Association). The impacts of enteric fermentation and manure management for almost 90 million animals are very significant, as seen in Figure 7.5. In both cases, carbon that was previously stored in biomass (cattle feed) is moved into the atmosphere, this time in the form of CH_4. This is another example of how humans have impacted the carbon cycle.

Previously in this chapter, you identified other ways the carbon cycle is impacted by human agriculture. Through industrialized agriculture, we must also account for the fossil fuels that are used. In order to deliver agricultural products to consumers, fossil fuels are used numerous times: deliveries of fertilizer, feed, and/or seed to farms; farm machinery; delivery of products to processers; food processing; delivery of foods to super markets; etc.

As animal products, especially meat, are expensive, the demand is typically greater in more-industrialized countries than it is in less-industrialized countries. This makes industrialized agriculture, and especially industrialized animal agriculture, one of the major contributors to greenhouse gas emissions in more-industrialized countries.

Knowledge check – answer these questions on your own to further explore the impacts of biomass and fossil fuel burning on the global carbon cycle.

1. Why is there a correlation between population growth rate and global distribution of biomass fires?
2. Do you think this correlation is more likely due to personal biomass fires for activities such as cooking, or due to slash-and-burn agriculture? Why?
3. Given any other knowledge you might have about the areas highlighted in in Figure 7.3c, what other environmental impacts may be occurring here besides carbon cycle alterations?
4. Compare the production of CO_2 emissions from fossil fuel combustion across world regions in 1900, 1950, and 2011 in Figure 7.4. What has accounted for these differences?
5. Has the total worldwide production of CO_2 from fossil fuels increased evenly relative to human population growth during the time period displayed in Figure 7.4? Why or why not?
6. What are the differences in contributions of greenhouse gas emissions from more-industrialized countries and less-industrialized countries? What are the similarities?

Resources

Carbon Dioxide Information Analysis Center http://cdiac.esd.ornl.gov/

NOAA Earth System Research Laboratory: Carbon Cycle Science
http://www.esrl.noaa.gov/research/themes/carbon/

Sass, Ronald. *Q2: What are the Causes of Global Climate Change?* OpenStax CNX. Sep 22, 2009 http://cnx.org/contents/5d263a29-7bd6-47bf-ad70-c233619bca33@3

USDA Climate Change and Agriculture in the United States: Effects and Adaptation http://www.usda.gov/oce/climate_change/effects_2012/effects_agriculture.htm

US EPA Overview of Greenhouse Gases: Methane http://epa.gov/climatechange/ghgemissions/gases/ch4.html

Woods Hole Oceanographic Institution: Carbon Around the Earth http://www.whoi.edu/feature/carboncycle/

Terms list

Aerobic

Anaerobic

Autotroph

Biomass

Carbon

Carbon dioxide

Cellular respiration

Chloroplast

Combustion

Consumption

Decomposition

Equilibrium

Flux

Greenhouse gas

Heterotroph

Industrial Revolution

Industrialized agriculture

Less-industrialized country

Lithosphere

Methane

More-industrialized country

Nitrous oxide

Ocean-atmosphere exchange

Photosynthesis

Potential energy

Primary producer

Reservoir

Residence time

Ruminant animal

Sink

Slash-and-burn agriculture

Source

What is causing global climate change?

Scientists have identified the source of our current global climate change as being the increased human-caused emissions of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), since the industrial revolution. Greenhouse gases are defined as large (at least three atoms) gas molecules that participate in the **greenhouse effect**. While you already know about the "big three" greenhouse gases (CO_2, CH_4, and N_2O), it's important to realize that **water vapor** (H_2O) is also a greenhouse gas. While humans have little direct impact on water vapor concentrations in the atmosphere, is it still an essential component of the natural greenhouse effect that occurs in our atmosphere.

The Earth receives energy from the sun and in turn radiates energy back into space. When these two energies are equal, a stable temperature of the Earth is achieved. This temperature can be calculated from basic physics and is equal to about 18°C (0°F). This **thermal equilibrium temperature** is obviously much colder than that of the surface of the Earth. The actual average value of the Earth's surface temperature is about 15°C (59°F). The difference between these temperatures is due primarily to the natural greenhouse gas concentrations in the atmosphere, causing the greenhouse effect. If the Earth had no naturally occurring atmospheric greenhouse gases, the temperature at the surface of the Earth would equal the thermal equilibrium temperature. The influence of these greenhouse gases, mainly water and some CO_2, moderates the Earth's climate and makes life possible (Figure 7.6).

As **solar radiation** reaches the Earth's atmosphere, there are a variety of possibilities for its fate. Some solar radiation is reflected by the Earth and its atmosphere, and does not contribute to warming. Some passes through the atmosphere and reaches the surface of the Earth. When this solar radiation is absorbed by objects on Earth's surface, it is re-emitted as infrared radiation (heat) that escapes to space. However, some of this heat is intercepted in the atmosphere by greenhouse gases. These gases absorb and re-emit the radiation in all directions. This creates a warming impact on the Earth's surface Radiation can be bounced around from one greenhouse gas molecule to another, becoming trapped, and increasing its warming potential. For this reason, an increased greenhouse gas concentration causes an increase in the overall warming potential of the Earth's atmosphere.

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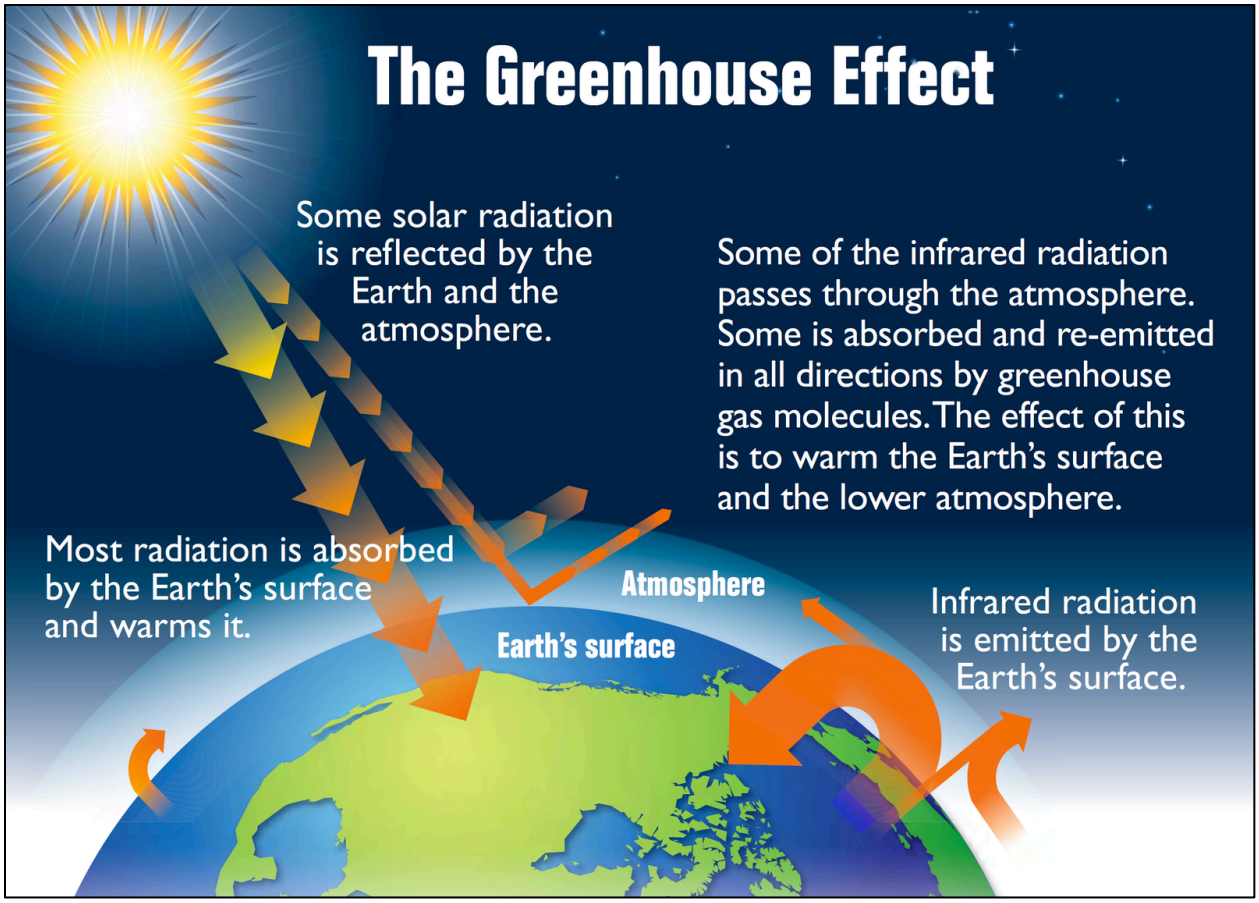


Figure 7.6. This diagram shows the Earth's greenhouse effect. The Earth absorbs some of the energy it receives from the sun and radiates the rest back toward space. However, certain gases in the atmosphere, called greenhouse gases, absorb some of the energy radiated from the Earth and trap it in the atmosphere. These gases essentially act as a blanket, making the Earth's surface warmer than it otherwise would be. While this greenhouse effect occurs naturally, making life as we know it possible, human activities in the past century have substantially increased the amount of greenhouse gases in the atmosphere, causing the atmosphere to trap more heat and leading to changes in the Earth's temperature. Credit: US EPA

On a geological time scale, the climate has changed many times in the past, even before the presence of humans. These changes occurred naturally because man had not yet evolved. A well-known example of past climate change is the occurrence of **ice ages**. Ice ages have occurred repeatedly throughout Earth's history, the most severe ice age of which scientists have reliable data occurred around 650,000 years ago. During this time, solid, glacial ice covered much of Canada, the northern United States, and northern Europe; the level of the ocean decreased 120 m, and the global average temperature decreased by 5°C.

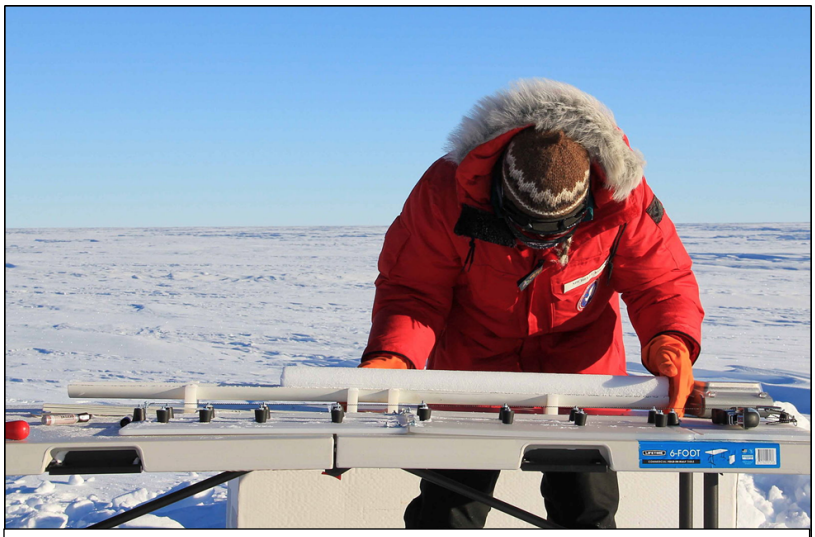


Figure 7.7. On Dec. 8, 2010, Michelle Koutnik, of the University of Copenhagen's Center for Ice and Climate, prepared a core of Antarctic ice to be wrapped and put into core tubes for transport back to labs at Brigham Young University in Utah. But first, Koutnik measured the core's length, diameter and weight. The traverse was the first of two field campaigns to study snow accumulation on the West Antarctic Ice Sheet and tie the information back to larger-scale data collected from satellites. Credit: NASA/Lora Koenig.

A geologic history of ice events is preserved in the ice sheets covering Antarctica and Greenland. This history has been uncovered over the past decades by scientists who have cored deeply into the ice and deciphered the temperature and atmospheric composition records stored in the ice. This process of obtaining **ice cores** is shown in Figure 7.7. The temperature at which the ice originally formed can be obtained from an interpretation of the measured ratio of the **stable isotopes** (see Chapter 1 supplement for a description of isotopes) of oxygen in the molecules of water forming the ice. The atmospheric gas composition is taken from air bubbles trapped in the ice at the time of formation. From these data, scientists have gathered a set of reliable data that track atmospheric temperature and gas concentrations that dates back 800,000 years. These data helped scientists come to the conclusion that the Earth's temperature and greenhouse gas concentrations are directly correlated to one another (Figure 7.8). During the ice age 650,000 years ago, the Earth was experiencing depressed temperature and atmospheric CO_2 concentrations below 200 **parts per million** (ppm). We can also see from these data, that CO_2 concentrations can be naturally elevated to as high as 300 ppm, correlating with increased temperatures.

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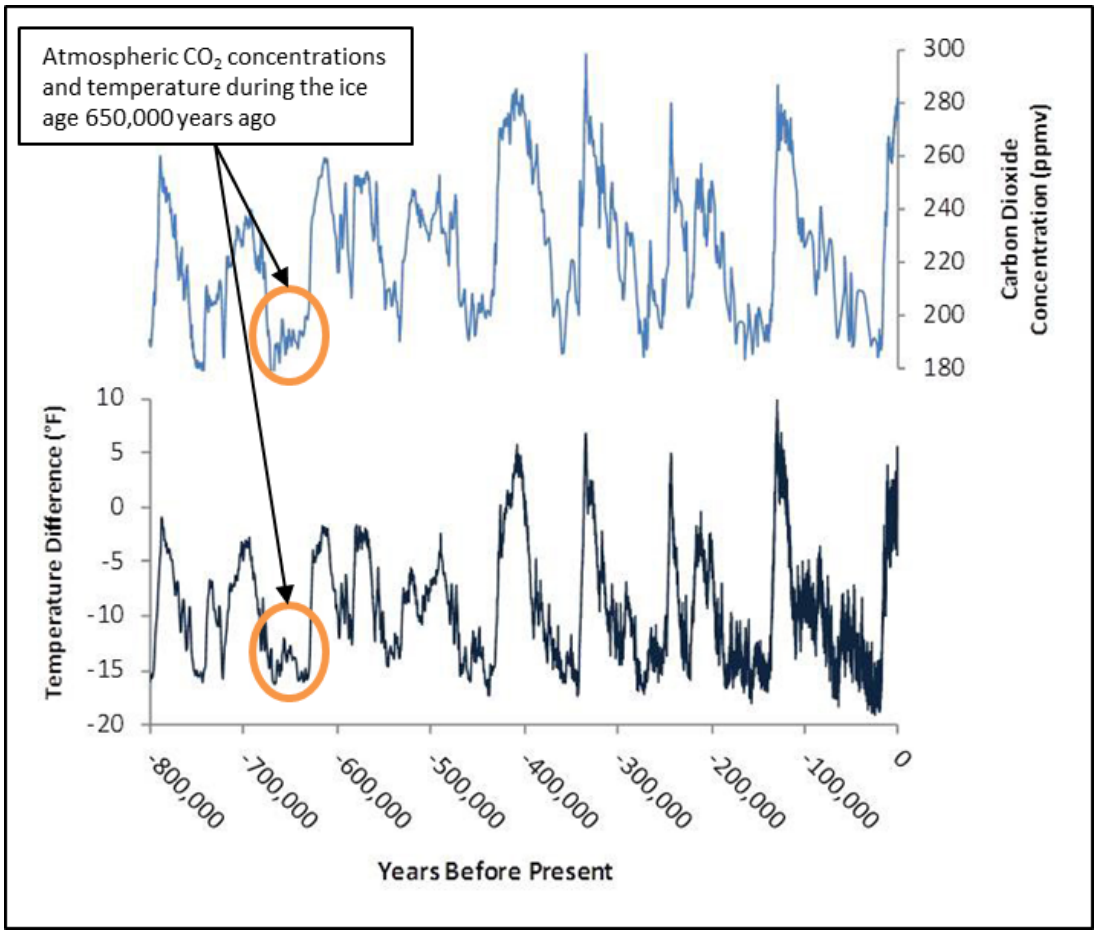


Figure 7.8. Estimates of the Earth's changing CO_2 concentration (top) and Antarctic temperature (bottom), based on analysis of ice core data extending back 800,000 years. Until the past century, natural factors caused atmospheric CO_2 concentrations to vary within a range of about 180 to 300 ppm. Warmer periods coincide with periods of relatively high CO_2 concentrations. NOTE: The past century's temperature changes and rapid CO_2 rise (to 400 ppm in 2015) are not shown here. Source: Based on data appearing in NRC (2010).

The 100,000 year major cycle of the ice ages and some variations within the cycles agree very well with predicted periodic relationships between the Earth's orbit around the sun, generally referred to as the **Milankovitch cycles**. Milankovitch cycles describe the very slight "wobbles" that occur in the Earth's tilt and path as it moves around the sun. The Earth is always slightly tilted on its axis with respect to the sun. The angle of this tilt, however, changes periodically, varying from about 22° to about 25°. A less severe tilt will cause milder summers and winters close to the poles, preventing full summer ice melt in the northern- and southernmost regions, and allowing for a buildup of ice from year to year.

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The path through which the Earth travels on its journey around the sun also changes from a more circular to a more elongated shape. Again, a round orbit will cause milder summers and winters close to the poles. These are very long term changes, and the results of the Milankovitch cycles can be observed in the changes in temperature and atmospheric CO_2 concentration shown in Figure 7.8. The climate change event that scientists are currently documenting is occurring much more rapidly than could be explained by Milankovitch cycles. Therefore, scientists agree that the cause of our currently changing climate is due to human impacts and not natural forces.

Greenhouse gases

We will be covering the four major categories of greenhouse gases that have been impacted by humans the most. See Table 7.2 for a numeric comparison of these greenhouse gases.

- Carbon dioxide, CO_2
- Methane, CH_4
- Nitrous oxide, N_2O
- Synthetic **fluorinated gases**, including **hydrofluorocarbons** (HFCs), **perfluorocarbons** (PFCs), and **sulfur hexafluoride** (SF_6)

Carbon dioxide (CO_2) is the greenhouse gas responsible for most of the human-caused climate change in our atmosphere. It has the highest concentration in the atmosphere of any of the greenhouse gases that we'll discuss here. Remember that CO_2 is a direct product of both combustion and cellular respiration, causing it to be produced in great quantities both naturally and anthropogenically. Any time biomass or fossil fuels are burned, CO_2 is released. Major anthropogenic sources include: electricity production from coal-fired and natural gas power plants, transportation, and industry (Chapter 4). To get an idea of how CO_2 concentration has changed over time, watch this video compiled by the National Oceanic and Atmospheric Administration (NOAA): http://www.esrl.noaa.gov/gmd/ccgg/trends/history.html. This video contains atmospheric CO_2 concentrations measured directly, dating back to 1958, as well as atmospheric CO_2 concentrations measured indirectly from ice core data, dating back to 800,000 BCE. By 1990, a quantity of over seven billion tons of carbon (equivalent to 26 billion tons of

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carbon dioxide when the weight of the oxygen atoms are also considered) was being emitted into the atmosphere every year, much of it from industrialized nations. Similar to the action of the naturally existing greenhouse gases, any additional greenhouse gases leads to an increase in the surface temperature of the Earth.

While CO_2 is produced by aerobic cellular respiration, gases such as CH_4 and N_2O are often the products of anaerobic metabolisms. Agriculture is a major contributor to CH_4 emissions, as you saw in section 7.1. In addition to anaerobic bacteria, methane is also a significant component of

natural gas, and is commonly emitted through the mining and use of natural gas and petroleum, in addition to coal mining. For a review of how fossil fuels are mined, see Chapter 4. Finally, **landfills** contribute significantly to CH_4 emissions, as the waste put into the landfill largely undergoes anaerobic decomposition as it is buried under many layers of trash and soil. Natural sources of CH_4 include swamps and wetlands, and volcanoes.

The vast majority of N_2O production by humans comes from agricultural land management. While some N_2O is naturally emitted to the atmosphere from soil as part of the nitrogen cycle, human changes in land management, largely due to agricultural practices, have greatly increased N_2O emissions. Some N_2O is also emitted from transportation and industry.

Due to their relatively high concentrations in the atmosphere compared to synthetic gases, CO_2, CH_4, and N_2O, are responsible for most of the human-caused global climate change over the past century. Figure 7.9 shows the increases in all three gases following the industrial revolution. Ice core data (Figure 7.8) shows us that the atmospheric CO_2 concentration never exceeded 300 ppm before the industrial revolution. As of early 2015, the current atmospheric CO_2 concentration is 400 ppm. Comparing Figure 7.9 to Figure 7.8, above, what is likely to happen to global temperature following this unprecedented rise in greenhouse gas levels?

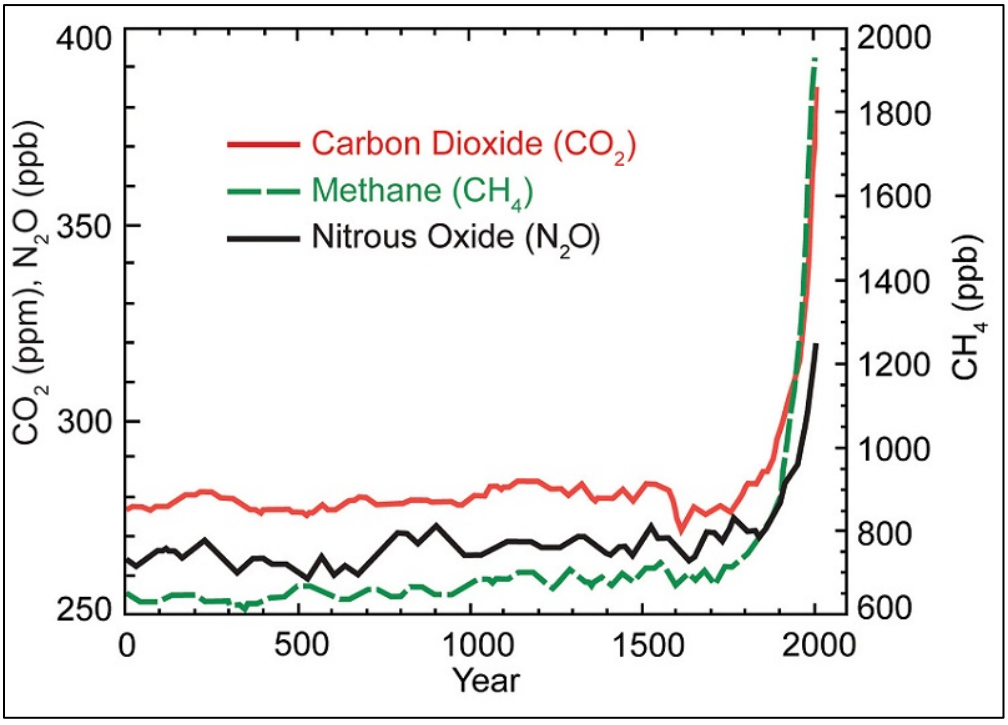


Figure 7.9. Increase in greenhouse gas concentrations in the atmosphere over the last 2,000 years. Increases in concentrations of these gases since 1750 are due to human activities in the industrial era. Concentration units are parts per million (ppm) or parts per billion (ppb), indicating the number of molecules of the greenhouse gas per million or billion molecules of air. Source: USGCRP (2009)

One class of greenhouse gas chemicals that has no natural sources is the fluorinated gases. These include HFCs, PFCs, and SF_6, among others. Because these are synthetic chemicals that are only created by humans, these gases were essentially non-existent before the industrial revolution. These synthetic gases are used for a wide variety of applications, from refrigerants to semiconductor manufacturing, and propellants to fire retardants. They tend to have a long lifetime in the atmosphere, as seen in Table 7.2. Some of these chemicals, as well as the older **chlorofluorocarbons** (CFCs), have been phased out by international environmental legislation under the Montreal Protocol (see Chapter 6). Due to their long lifespan, many of these now-banned CFCs remain in the atmosphere. Newer chemical replacements, such as HFCs, provide many of the same industrial applications, but unfortunately have their own environmental consequences.

Just as greenhouse gases differ in their sources and their residence time in the atmosphere, they also differ in their ability to produce the greenhouse effect. This is measured by the **global warming potential**, or GWP, of each greenhouse gas. The GWP of a greenhouse gas is based on its ability to absorb and scatter energy, as well as its lifetime in the atmosphere. Since CO_2 is the most prevalent greenhouse gas, all other greenhouse gases are measured relative to it. As the reference point, CO_2 always has a GWP of 1. Note the very high GWP values of the synthetic fluorinated gases in Table 7.2. This is largely due to their very long residence time in the atmosphere. Also note the higher GWP values for CH_4 and N_2O compared to CO_2. How does this impact the comparison of the environmental effects of agricultural practices in less-industrialized and more-industrialized countries that we completed in section 7.1?

Table 7.2. Comparison of common greenhouse gases in the atmosphere. Data from US EPA. For more information: http://epa.gov/climatechange/ghgemissions/gases.html

Greenhouse gas	Chemical formula or abbreviation	Lifetime in atmosphere	Global warming potential (100-year)
Carbon dioxide	CO_2	Variable	1
Methane	CH_4	12 years	28-36
Nitrous oxide	N_2O	114 years	298
Hydrofluorocarbons	Abbreviation: HFCs	1-270 years	12-14,800
Perfluorocarbons	Abbreviation: PFCs	2,600-50,000 years	7,390
Sulfur hexafluoride	SF_6	3,200 years	22,800

Other climate influencers

In addition to greenhouse gases, other manmade changes may be forcing climate change. Increases in near surface ozone from internal combustion engines, aerosols such as carbon black, mineral dust and aviation-induced exhaust are acting to raise the surface temperature. This

primarily occurs due to a decrease in the **albedo** of light-colored surfaces by the darker-colored carbon black, soot, dust, or particulate matter. As you know, it is more comfortable to wear a white shirt on a hot summer day than a black shirt. Why is this? Because the lighter-colored material bounces more solar radiation back toward space than the darker-colored material does, allowing it to stay cooler. The darker-colored material absorbs more solar radiation, increasing its temperature. Just as the white shirt has a higher albedo than the black shirt, light-colored objects in nature (such as snow) have a higher albedo than dark-colored objects (such as soot or dust). As humans increase the amount of carbon black, soot, dust, and particulates in the atmosphere, we decrease the albedo of light-colored surfaces, causing them to absorb more solar radiation and become warmer than they would without human influence. An example of this can be seen in the snow on Figure 7.10.



Figure 7.10. A photograph of the extreme dust deposition from the deserts of the Colorado Plateau onto the Colorado Rockies snowpack in 2009. Taken from the high point of the Senator Beck Basin in the San Juan Mountains, it captures the extent of the impact of darkening in which the snow albedo dropped to about 30%, more than doubling the absorption of sunlight. Credit: S. McKenzie Skiles, Snow Optics Laboratory, NASA/JPL

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Tools scientists use to study climate change

Scientists must gather together all data that is available to them in order to make meaningful conclusions and predictions regarding climate change. When they bring these data together, the prediction they make is in the form of a scientific **model**. A model is a projection of what might happen in the future based on knowledge of current and past events. The models that are published to predict climate change must pass a rigorous scientific peer-review process, and often require the combination of findings of hundreds of experiments. These large-scale models are typically beyond the capacity of a standard desktop computer, and must be run by large super-computers housed at research universities or government laboratories. For more information on how scientists build and test models, follow the link below and click on the slideshow animation, paying special attention to the sections "Model Overview" and "Testing Models." http://www.epa.gov/climatechange/science/future.html

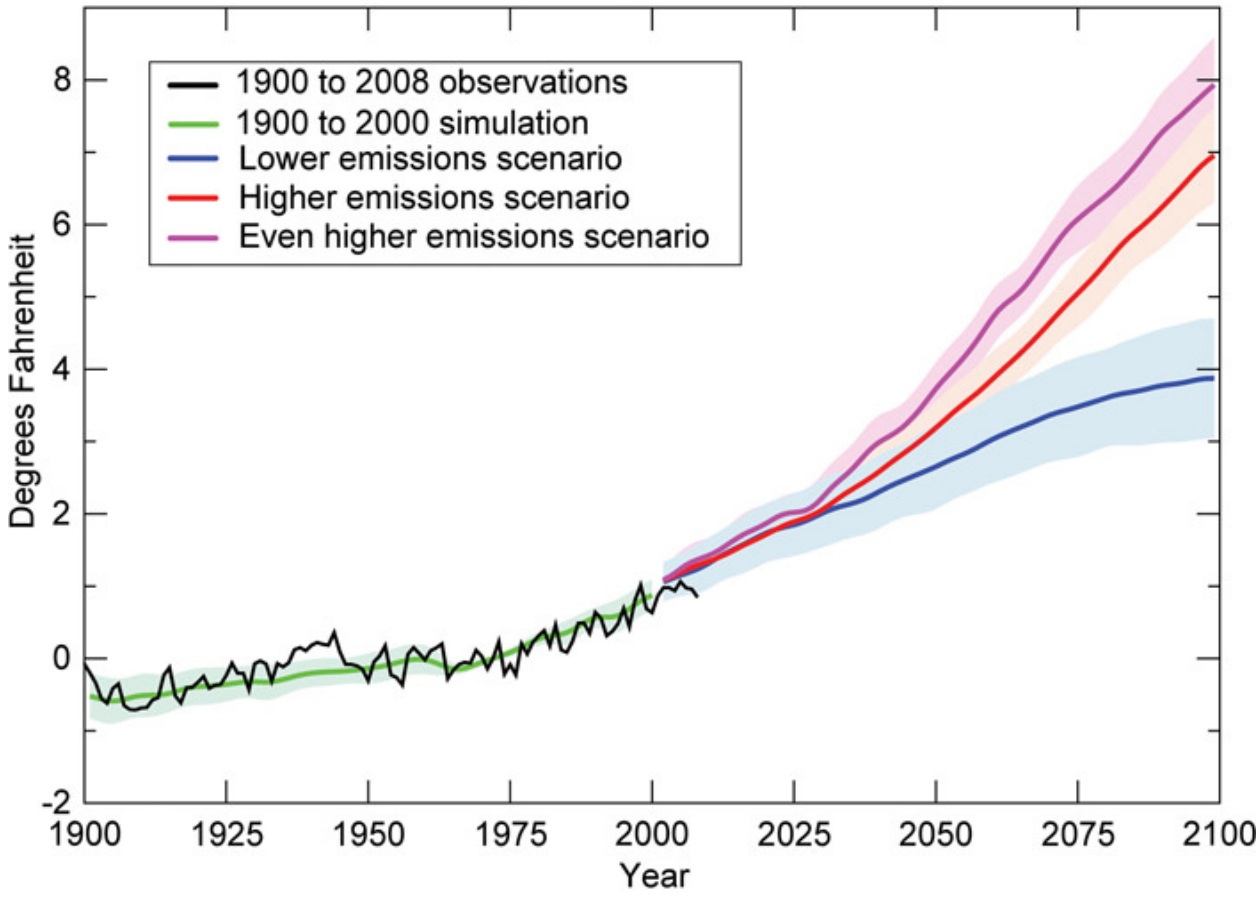


Figure 7.11. Observed and projected changes in global average temperature under three no-policy emissions scenarios. The shaded areas show the likely ranges while the lines show the central projections from a set of climate models. A wider range of model types shows outcomes from 2 to 11.5°F. Changes are relative to the 1960-1979 average. Source: USGCRP 2009

Figure 7.11 is one example of a scientific model of the impacts of climate change. Within this figure, we see the directly-measured observations of global average temperature (black line). We also see models of four different scenarios: 1900 to 2000 simulation using actual greenhouse emissions (green line), and 2000 to 2100 simulation using very high (purple line), high (red line), and low (blue line) greenhouse gas emissions scenarios.

Why did scientists make a model of the data from 1900 to 2000 in Figure 7.11 when they could just look up the data in published literature? This is an important component of model testing. In order to ensure accuracy of the model, you should not only be able to predict future events, but past events as well. Scientists use this as a way to "calibrate" their model. Since this model reliably predicts past events, chances are good that it will reliably predict future events as well.

Another example of a climate model is shown in Figure 7.12, this time comparing climate projections with and without the influences of humans on greenhouse gas emissions. This large model is a combination of the work of many different models, in order to achieve the most accurate outcome.

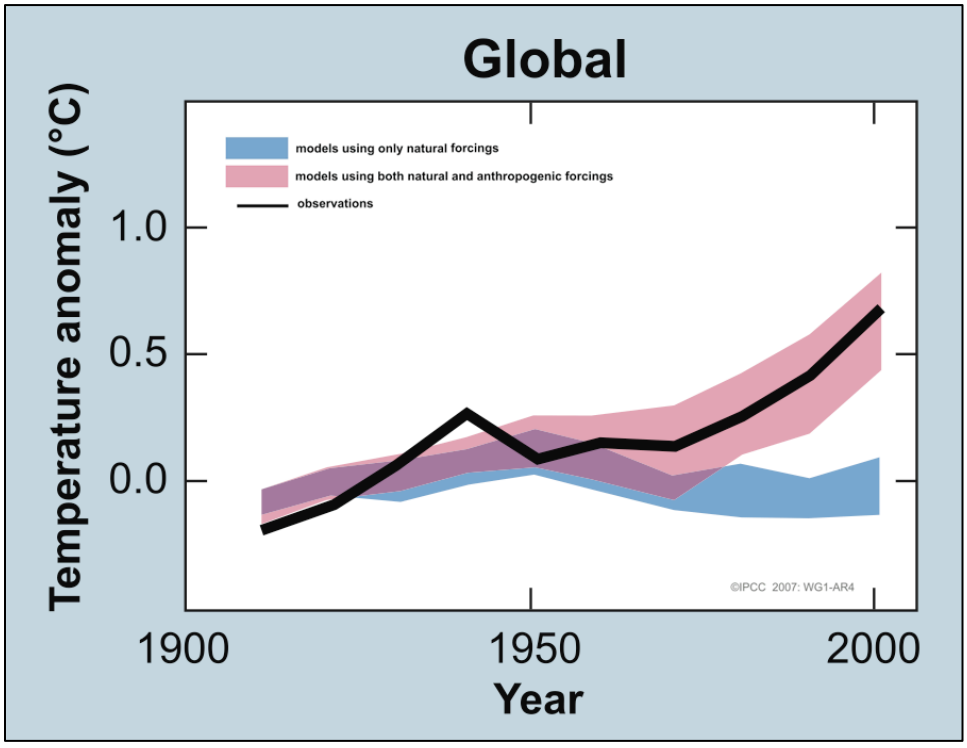


Figure 7.12. Comparison between observed average global temperatures and corresponding modeled temperatures with and without anthropogenic climate forces (IPCC, Working group 1, 2007).

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In Figure 7.12, the decadal averages of observations are shown for the period 1906 to 2005 (black line). All temperatures are plotted relative to zero being defined as the corresponding average for the period from 1901 to 1950. The blue shaded band shows the 5% to 95% **confidence interval** for 19 simulations from 5 climate models using only the natural forcing effects due to solar activity and volcanoes. The red shaded band shows the 5% to 95% confidence interval for 58 different simulations from 14 climate models using both natural and anthropogenic forces. These different simulations and the different models are used by different scientific groups and represent different treatments of the Earth's systems. It is thus quite encouraging that model calculations are in major agreement with the assumption that global temperature change from 1900 to 2000 is due to both natural and anthropogenic effects, with anthropogenic effects being the major causes in its recent dramatic increase.

You will see more examples of climate models as you make your way into the final section of the climate change chapter: consequences of climate change.

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Resources

NASA Global Climate Change: Vital Signs of the Planet http://climate.nasa.gov/

NOAA Paleoclimatology: Astronomical Theory of Climate Change http://www.ncdc.noaa.gov/paleo/milankovitch.html

Sass, Ronald. *Q2: What are the Causes of Global Climate Change?* OpenStax CNX. Sep 22, 2009 http://cnx.org/contents/5d263a29-7bd6-47bf-ad70-c233619bca33@3

University of San Diego Virtual Museum: Climate Change http://earthguide.ucsd.edu/virtualmuseum/climatechange2/01_1.shtml

US EPA: Future Climate Change http://www.epa.gov/climatechange/science/future.html

US EPA: Overview of Greenhouse Gases http://epa.gov/climatechange/ghgemissions/gases.html

Terms list

Albedo

Chlorofluorocarbon

Confidence interval

Fluorinated gases

Global warming potential

Greenhouse effect

Hydrofluorocarbon

Ice age

Ice core

Landfill

Milankovitch cycles

Model

Parts per million

Perfluorocarbon

Solar radiation

Stable isotopes

Sulfur hexafluoride

Thermal equilibrium temperature

Water vapor

Consequences of Climate Change

As part of your assigned reading for this section, read the article "The Coming Storm" by Don Belt published in *National Geographic*:
http://ngm.nationalgeographic.com/print/2011/05/bangladesh/belt-text

In this section, we will discuss the effects of climate change, both those that have already been observed, as well as future predictions based on scientific climate models (see section 7.2 for a discussion of scientific models). Here, the differences between the terms **global warming** and **climate change** become apparent. Global warming refers to the increase in the average temperature of the Earth's atmosphere due to elevated greenhouse gas concentrations, heightening the greenhouse effect. We have already observed this increase occurring, as you saw in Figure 7.12 from section 7.2. We have also seen, and expect to continue to see, other changes occurring in the **climate** of the Earth. Furthermore, changes have been observed, and we expect to continue to observe, changes in other chemical, physical, and biological aspects of the Earth's environment. We will only discuss some of the consequences of climate change in this section, including changes in temperature, precipitation, ocean level, and ocean acidity. There are many more changes that have been seen, and are projected to continue in the future. These include: changes in the amount and distribution of ice and snow, changes in seasonality, ecosystem shift, and habitat changes of plant and animal populations, in addition to others. For more information about these consequence of climate change, visit this site:
http://www.epa.gov/climatechange/science/indicators/index.html.

Temperature and precipitation

Temperature and **precipitation** are the two most direct impacts on the Earth's climate due to climate change. By now, you should already understand why an increase in greenhouse gas levels in the atmosphere causes an increase in temperature. But why does it also impact precipitation patterns? As you already know, water vapor is an important component of the Earth's atmosphere (see Chapter 6). As the air in the troposphere warms and cools, the amount of water vapor that it holds changes dramatically. Here in Georgia, we have very hot and humid summers. The high summer humidity in this region is possible due to the increased capability warm air has to hold water vapor. Simply put, warmer air can hold more water than cooler air. As air cools, its ability to hold water vapor decreases, and any excess water will leave the air as liquid water. A great example of this is the formation of dew on surfaces overnight. During the day, the temperature is warmer than it is at night, and the air has a relatively high holding capacity for water vapor. When the sun sets, the air cools, decreasing its capacity to hold water vapor. That extra water must go somewhere, and it does that by accumulating on surfaces. Similarly, when warm and cool air fronts collide, the chances for rain and thunderstorms increase. Furthermore, an increase in temperature enhances evaporation occurring at the Earth's

surface. This increased evaporation leads to greater concentrations of water vapor in the atmosphere which can lead to increased precipitation.

The change in temperature that we have already seen in the Earth's average atmospheric temperature is relatively small (about 0.6 °C, according to Figure 7.12 from section 7.2). However, as with many of the aspects of climate change, the potential for greater changes increases dramatically as time progresses in the future. This can be seen in Figure 7.13, which displays a model of the predicted temperature increase. Notice that these changes occur relatively rapidly, and are not uniform across the globe. What might be some of the reasons for this?

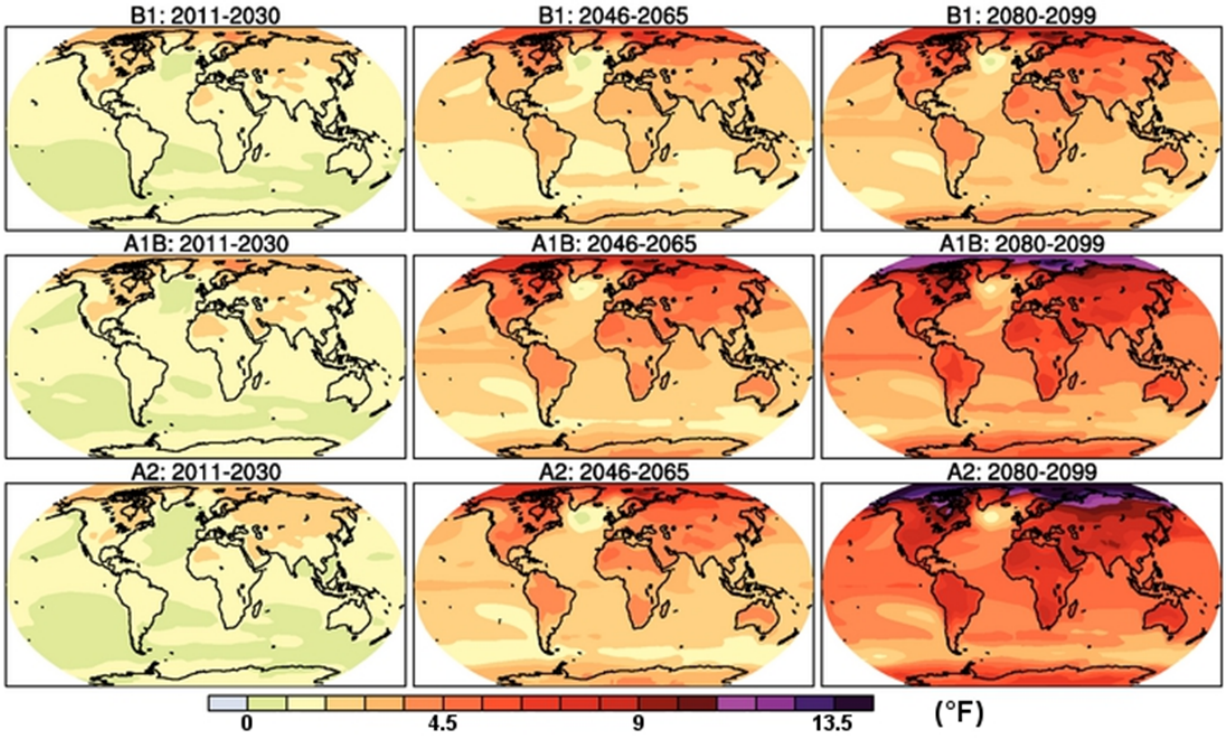


Figure 7.13. Projected changes in global average temperatures under three emissions scenarios (rows) for three different time periods (columns). Changes in temperatures are relative to 1961-1990 averages. The scenarios come from the IPCC Special Report on Emissions Scenarios: B1 is a low emissions scenario, A1B is a medium-high emissions scenario, and A2 is a high emissions scenario. Source: IPCC Working Group I: The Physical Science Basis, 2007.

Changes in precipitation occur due to a variety of factors, including changes in atmospheric water vapor content due to changing temperature, as discussed above. Also at play is the heightened **evaporation** rate of water on Earth's surface under warmer temperatures. More evaporation leads to more precipitation. Finally, shifts in wind patterns impact the distribution of precipitation events. As you can see in Figure 7.14, there are some areas of the globe that are expected to have an increase in precipitation, while others are expected to have a dramatic

decrease. Some major population centers projected to have a moderate to severe precipitation increase include (population estimates of the metropolitan area given in parentheses): New York, United States (20.1 million); Bogotá, Colombia (12.1 m.); and Manila, Philippines (11.9 m.). What sort of challenges might these cities face in the future as they deal with this change in their climate?

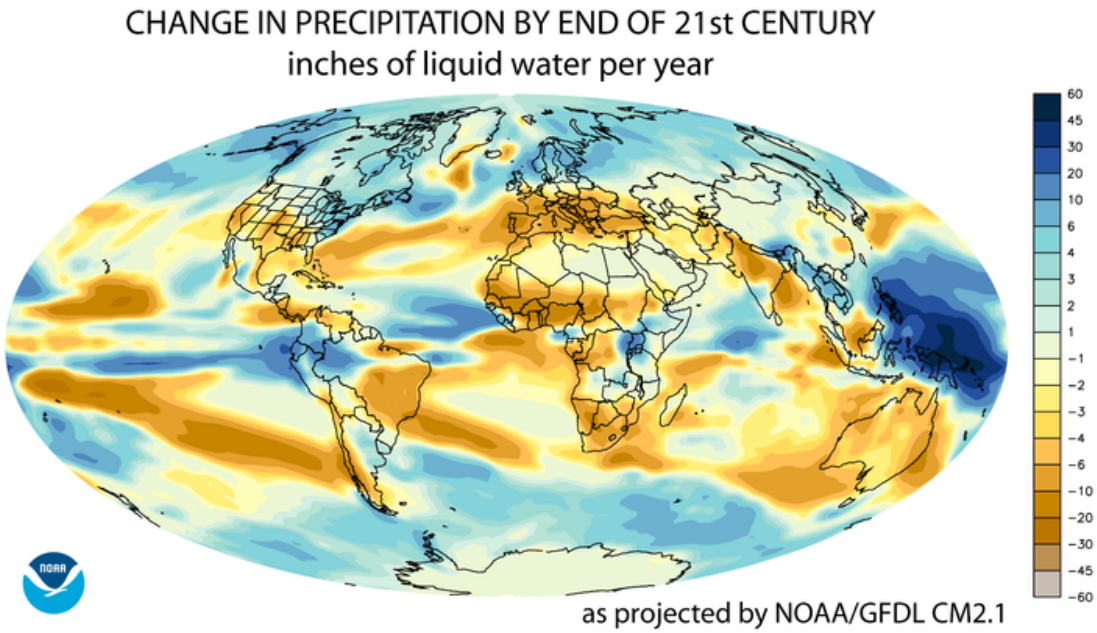


Figure 7.14. Change in annual average precipitation projected by the NOAA Geophysical Fluid Dynamics Laboratory (GFDL) by the GFDL CM2.1 model for the 21st century based on the A1B emissions scenario (see Figure 7.13). The plotted precipitation differences were computed as the difference between the 2081 to 2100 20-year averages minus the 1951 to 2000 50-year average. Blue areas project increases in precipitation; brown areas project decreases.

In contrast, many more major metropolitan areas are projected to have a moderate to severe precipitation decrease (droughts) by the end of the 21st century. These include Delhi, India (21.8 m.); Lagos, Nigeria (21 m.); São Paulo, Brazil (20.9 m.); Kolkata, India (14.6 m.); Istanbul, Turkey (14.4 m.); Los Angeles, United States (13.3 m.); Rio de Janeiro, Brazil (12 m.); Paris, France (12 m.); and Lahore, Pakistan (11.3 m.). The largest challenge that these areas are likely to face is a dwindling water supply for drinking and agriculture. See Chapter 8 for more detail on challenges faced by societies to supply clean, reliable water to their populations and farms.

Additional challenges may be felt by all areas of the world with regard to changes in the seasonality or timing of precipitation, as well the form in which precipitation falls (e.g., mist or downpour; rain, ice, or snow). All of these factors affect the availability of soil water for plants,

the flow of rivers and streams, and the overall accessibility of water worldwide. Furthermore, scientists predict an increase in the number and severity of storms as climate change progresses. For a full discussion of the potential impacts of this, see the assigned article.

Sea level rise

While we know that water continuously cycles around the world (see Chapter 8 for information on the water cycle), and that the overall quantity of water on Earth will not change due to global climate change, the distribution of this water is changing. In particular, oceans are increasing in volume while land ice stores (such as **glaciers**) are decreasing. This contributes to an increase in sea level worldwide (Figure 7.15).

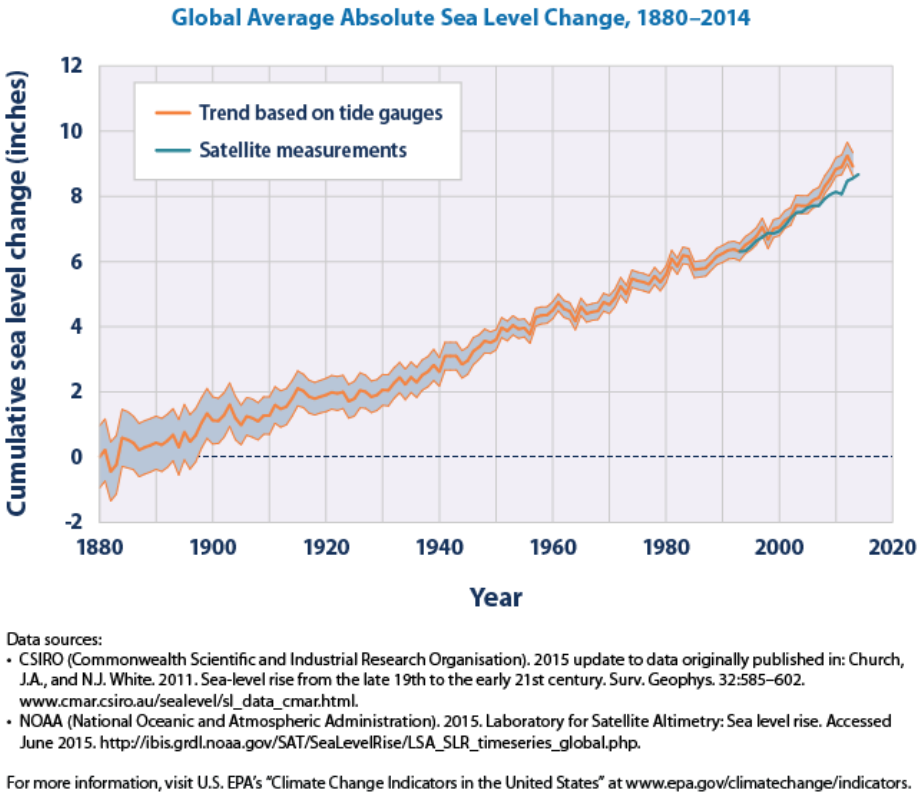


Figure 7.15. This graph shows average absolute cumulative changes in sea level for the world's oceans since 1880, based on a combination of tide gauge measurements and recent satellite measurements. The shaded band shows the likely range of values, based on the number of measurements collected and the precision of the methods used.

From the data in Figure 7.15, we see that sea level has increased at an average of 0.06 inches (0.15 cm) per year over the time period shown above. Most of this rise, however, has occurred within the most recent decades. The rate of increase has gone up to between 0.11 to 0.14 inches

Photographs of McCall Glacier, Alaska, 1958 and 2003



Sources:
- Post, A. 1958. McCall Glacier. Glacier photograph collection. Boulder, Colorado: National Snow and Ice Data Center/World Data Center for Glaciology. http://nsidc.org/data/g00472.html.
- Nolan, M. 2003. McCall Glacier. Glacier photograph collection. Boulder, Colorado: National Snow and Ice Data Center/World Data Center for Glaciology. http://nsidc.org/data/g00472.html.

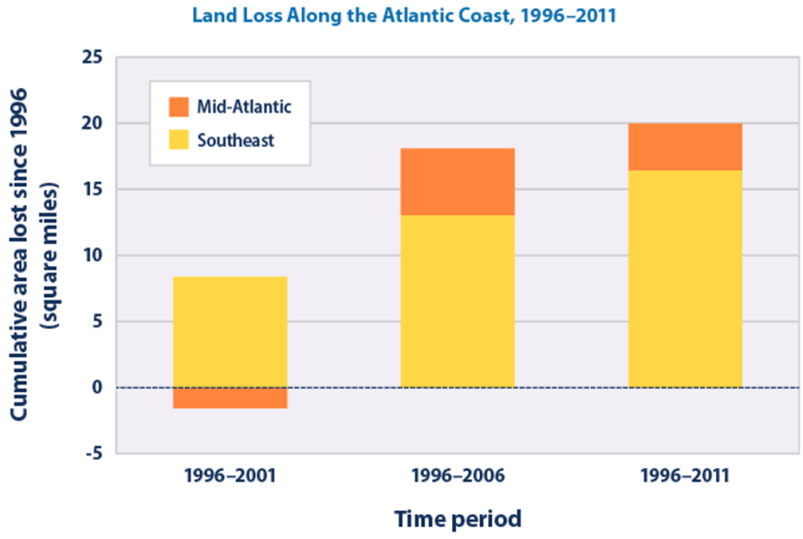
For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climatechange/indicators.

(0.28 to 0.36 cm) per year since 1993. There are two forces causing sea level to rise, both caused by climate change. First, the increased global temperature has caused increased ice melting in many regions of the globe. Melting **land ice** (such as the glacier shown in figure 7.16) contributes to sea level rise because water that used to be stored in ice sitting on top of land becomes running water which reaches the ocean through **runoff**. We also observe **sea ice** melting (see http://www.epa.gov/climatechange/science/indicators/index.html for data and figures). Sea ice, such as the ice that covers the arctic regions of the Northern Hemisphere, has no land underneath it. When it melts, the water stays in the same locations, and the overall sea level does not change.

The second factor that influences sea level rise is a phenomenon called **thermal expansion**. Due to the physical properties of water, as water warms, its density decreases. A less dense substance will have fewer molecules in a given area than a more dense substance (see Chapter 1 supplemental material). This means that as the overall temperature of the oceans increases due to global climate change, the same amount of water molecules will now occupy a slightly larger volume. This may not seem significant, but considering the 1.3 billion trillion liters (264 billion gallons) of water in the ocean, even a small change in density can have large effects on sea level as a whole.

Scientists have already documented sea level rise in some areas of the world, including one familiar to most of us: the Southeastern United States. Figure 7.17 depicts the measured land area lost due to increasing sea level since 1996. Note that the Southeast (defined here as the

Atlantic coast of North Carolina south to Florida) is particularly susceptible to land area loss due to the gently sloping nature of our coastline. Moving northward into the Mid-Atlantic States (defined here as Virginia north to Long Island, New York), coastal habitats tend to have a steeper geography, which protects against some losses.



Data source: NOAA (National Oceanic and Atmospheric Administration). 2013. Coastal Change Analysis Program. Accessed December 2013. www.csc.noaa.gov/digitalcoast/data/ccapregional.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climatechange/indicators.

Figure 7.17. This graph shows the net amount of land converted to open water along the Atlantic coast during three time periods: 1996–2001, 1996–2006, and 1996–2011. The results are divided into two regions: the Southeast and the Mid-Atlantic. Negative numbers show where land loss is outpaced by the accumulation of new land.

While the ecological effects of sea level rise remain in the United States, we don't project any catastrophic loss of life, property, or livelihood for some time. This is, in part, due to large investments that we have made in infrastructure to protect our cities and farmlands. This is not the case in many areas of the world. For a discussion of the impacts of sea level rise on less-industrialized nations of Bangladesh, Maldives, Kiribati, and Fiji, review the required article reading.

Ocean acidification

Dissolved CO_2 is essential for many organisms, including shell-building animals and other organisms that form a hard coating on their exterior (e.g., shellfish, corals, Haptophyte algae). This hard coating is built out of **aragonite**, a mineral form of the molecule **calcium carbonate**,

$CaCO_3$. These organisms rely on the formation of **carbonate** ions (see Chapter 1 supplemental material for information on ions), CO_3^{2-}, from dissolved CO_2, through a natural, chemical reaction that occurs. This takes place through a chain-reaction equation, where **bicarbonate** (HCO_3^-) is formed as an intermediate, and **hydrogen ions** (H^+) are generated (equations 7.3 and 7.4).

$$CO_2 + H_2O \leftrightarrow H^+ + HCO_3^- \qquad \textbf{Eq. 7.3}$$

$$HCO_3^- \leftrightarrow H^+ + CO_3^{2-} \qquad \textbf{Eq. 7.4}$$

To have a better visualization of this process, follow along with the interactive graphic at: http://www.whoi.edu/home/oceanus_images/ries/calcification.html.

As you can see, both equations 7.3 and 7.4 each produce one H^+. This is significant to water chemistry because an increase in H^+ concentration means a decrease in the **pH** of the water. You can see in Figure 7.18 that a lower pH means that the liquid is more **acidic**. As shown in the interactive graphic, an increase in CO_2 in the atmosphere causes additional CO_2 to be dissolved in the ocean. This means that more CO_2 in the atmosphere leads to more acidic ocean environments.

Unfortunately for shell-building animals, the buildup of H^+ in the more acidic ocean environment blocks the absorption of calcium and CO_3^{2-}, and makes the formation of aragonite more difficult. An aragonite deficit is already being documented in many of the world's oceans, as shown in Figure 7.19.

The increasing acidity of the world's oceans is resulting in habitat changes across the globe. This is only expected to worsen as atmospheric CO_2 levels continue to increase. Many organisms, including the corals that are the foundation species of the beautiful coral reefs, are very sensitive to changes in ocean pH. Scientists have documented cases of ecosystem destruction through **coral bleaching**, caused by the effects of climate change including ocean acidification and increased temperature. For

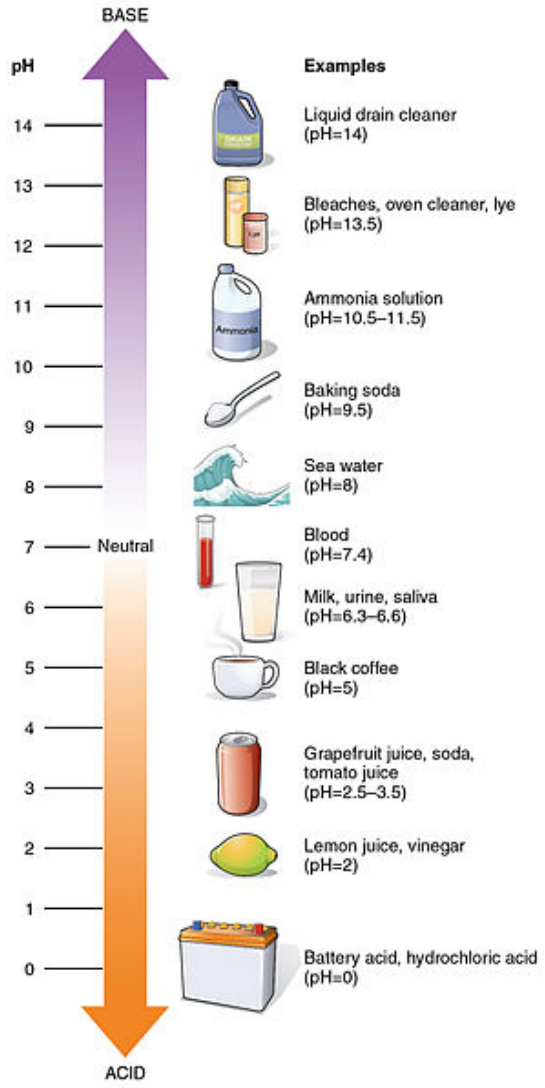


Figure 7.18. The pH scale and relative acidity. Illustration from Anatomy & Physiology, Connexions Web site. http://cnx.org/content/col11496/1.6/, Jun 19, 2013.

more information, visit the NOAA Coral Reef Conservation Program website: http://coralreef.noaa.gov/threats/climate/.

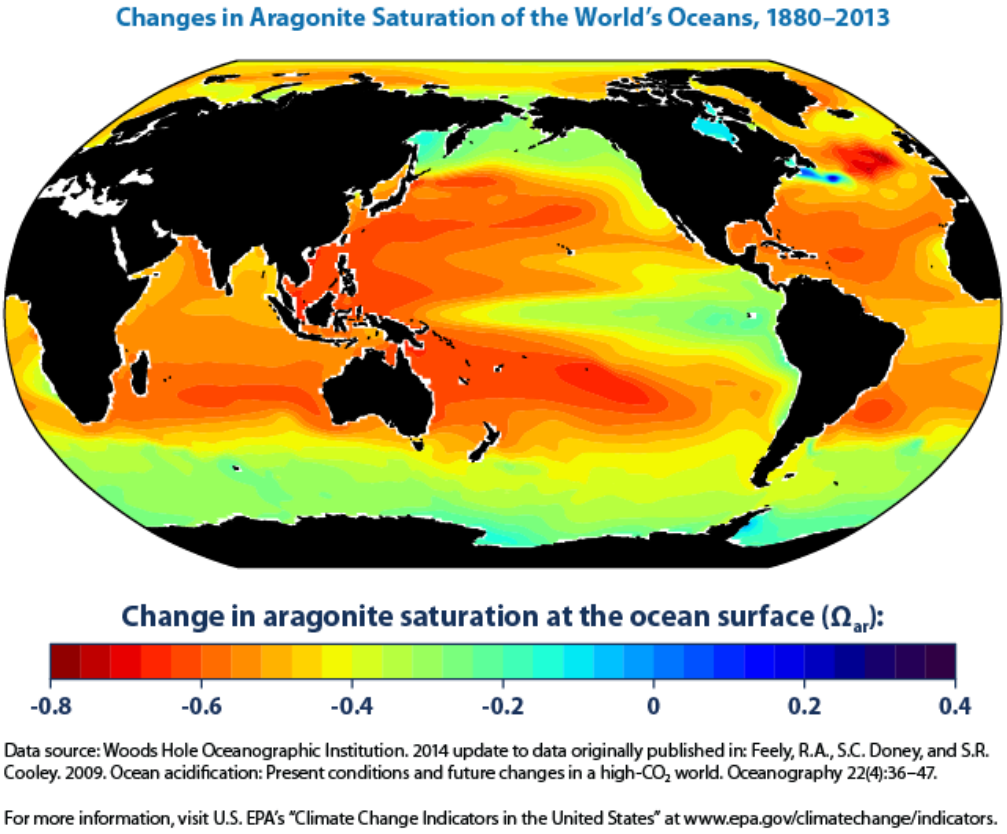


Figure 7.19. This map shows changes in the aragonite saturation level of ocean surface waters between the 1880s and the most recent decade (2004–2013). Aragonite is a form of calcium carbonate that many marine animals use to build their skeletons and shells. A negative change represents a decrease in saturation.

Looking Forward: Climate Solutions

While the situation surrounding global climate change is in serious need of our attention, it is important to realize that many scientists, leaders, and concerned citizens are making solutions to climate change part of their life's work. The two solutions to the problems caused by climate change are **mitigation** and **adaptation**, and we will likely need a combination of both in order to prosper in the future.

Adaptation strategies

We know that climate change is already occurring, as we can see and feel the effects of it. For this reason, it is essential to also adapt to our changing environment. This means that we must

change our behaviors in response to the changing environment around us. Some adaptation strategies are discussed in the required article reading.

Adaption strategies will vary greatly by region, depending on the largest specific impacts in that area. For example, in the city of Delhi, India, a dramatic decrease in rainfall is projected over the next century (Figure 7.14). This city will likely need to implement policies and practices relating to conservation of water, for example: rainwater harvesting, water re-use, and increased irrigation efficiency. Rain-limited cities near oceans, such as Los Angeles, California may choose to use **desalination** to provide drinking water to their citizens. Desalination involves taking the salt out of seawater to make it potable (Chapter 8).

Cities with low elevations near oceans may need to implement adaptation strategies to rising sea levels, from seawalls and levees to relocation of citizens. One adaptations strategy gaining use is the creation or conservation of **wetlands**, which provide natural protection against storm surges and flooding.

Mitigation strategies

In general, a strategy to mitigate climate change is one that reduces the amount of greenhouse gases in the atmosphere or prevents additional emissions. Mitigations strategies attempt to "fix" the problems caused by climate change. Governmental regulations regarding fuel efficiency of vehicles is one example of an institutionalized mitigation strategy already in place in the United States and in many other countries around the world. Unlike some other countries, there are no **carbon taxes** or charges on burning fossil fuels in the United States. This is another governmental mitigation strategy that has been shown to be effective in many countries including India, Japan, France, Costa Rica, Canada, and the United Kingdom.

In addition to government measures and incentives, technology can also be harnessed to mitigate climate change. One strategy for this is the use of **carbon capture and sequestration** (CCS). Through CCS, 80-90% of the CO_2 that would have been emitted to the atmosphere from sources such as a coal-fired power plant is instead captured and then stored deep beneath the Earth's surface. The CO_2 is often injected and sequestered hundreds of miles underground into porous rock formations sealed below an impermeable layer, where it is stored permanently (Figure 7.20).

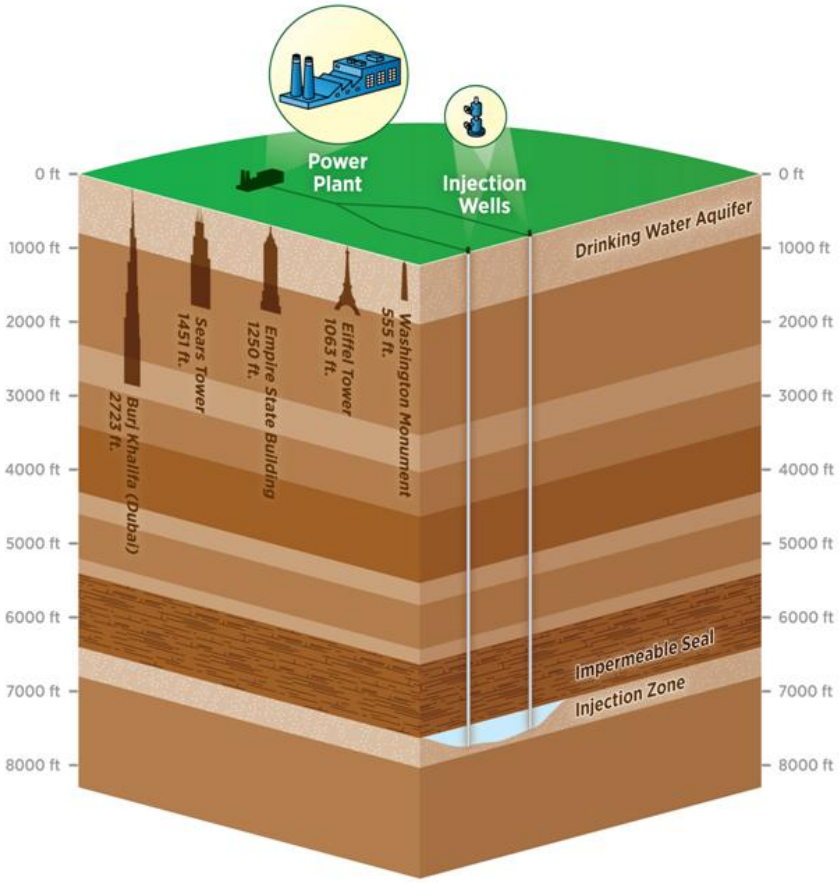


Figure 7.20. Carbon capture and sequestration schematic with landmarks shown to scale for depth reference. Source: US EPA.

Scientists are also looking into the use of soils and vegetation for carbon storage potential. Proper management of soil and forest ecosystems has been shown to create additional carbon sinks for atmospheric carbon, reducing the overall atmospheric CO_2 burden. Increasing soil carbon further benefits communities by providing better-quality soil for agriculture and cultivation.

Technologies related to alternative energy sources (Chapter 5) mitigate climate change by providing people with energy not derived from the combustion of fossil fuels. Finally, simple activities such as energy conservation, choosing to walk or bike instead of driving, and disposing of waste properly are activities that, when done by large numbers of people, actively mitigate climate change by preventing carbon emissions.

Take a moment to identify ways that you personally can be involved in the mitigation of or adaptation to climate change. What changes can you make in your own life to prevent excess carbon emissions? Similar to your ecological footprint, which you should have already calculated in lab, you can also calculate your **carbon footprint**. Use the EPA's carbon footprint

calculator to do so, and investigate the Reduce Your Emissions section to find ways to decrease your carbon footprint.

Resources

Belt, Don. "The Coming Storm." *National Geographic Magazine*, May 2011. http://ngm.nationalgeographic.com/print/2011/05/bangladesh/belt-text

IPCC Fourth Assessment Report: Climate Change 2007 Synthesis Report. 4. Adaptation and mitigation options https://www.ipcc.ch/publications_and_data/ar4/syr/en/spms4.html

NOAA Coral Reef Conservation Program: Climate Change http://coralreef.noaa.gov/threats/climate/

NOAA Geophysical Fluid Dynamics Laboratory: Will the wet get wetter and the dry drier? http://www.gfdl.noaa.gov/will-the-wet-get-wetter-and-the-dry-drier

Ontl, Todd and Lisa Schulte (2012) Soil Carbon Storage. Nature Education Knowledge 3(10):35 http://www.nature.com/scitable/knowledge/library/soil-carbon-storage-84223790

US EPA Carbon Dioxide Capture and Sequestration http://www.epa.gov/climatechange/ccs/

US EPA Carbon Footprint Calculator http://www3.epa.gov/carbon-footprint-calculator/

US EPA Climate Change Indicators in the United States http://www.epa.gov/climatechange/science/indicators/index.html

Terms list

Acidity

Adaptation

Aragonite

Bicarbonate

Calcium carbonate

Carbon capture and sequestration

Carbon footprint

Carbon tax

Carbonate

Climate

Climate change

Coral bleaching

Desalination

Evaporation

Glacier

Global warming

Hydrogen ions

Land ice

Mitigation

pH

Precipitation

Runoff

Sea ice

Thermal expansion

Wetland

CHAPTER 8: WATER

Learning Objectives

As a result of this unit:

- Students will be able to draw multiple interacting water molecules and identify the bonds and atoms
- Students will explain how the molecular structure of the water molecule contributes to the unique properties of water.
- Students will demonstrate an understanding of how much water is available on Earth and how it is distributed
- Students will be able to compare regional and national responses to water issues.
- Students will be able to explain water-related problems (for example water scarcity, water-borne diseases, water pollution, flooding) from different regions of the world
- Students will be able to explain how human modifications of natural water systems can be both beneficial and destructive
- Students will be able to describe solutions to water-related problems
- Students will be able to read and interpret graphs and charts about water
- Students will demonstrate knowledge of some of the major regulations related to water in the USA
- Students will gain a rudimentary understanding of groundwater flow, management and protection

CHAPTER 8: WATER

This chapter has been adapted from OpenStax (Biology and Concepts in Biology texts), USGS Water Resources, the EPA and The Encyclopedia of Earth

"Whiskey is for drinking. Water is for fighting"

Introduction

Why do scientists spend time looking for water on other planets? Why is water so important? It is because water is essential for life as we know it. Water is one of the more abundant molecules and the one most critical to life on Earth. Approximately 60–70 percent of the human body is made up of water. Without it, life as we know it simply would not exist. The quotation above, which has been attributed to Mark Twain, suggested (by the quote above) that water was extremely important. In recent years, we have seen a rise in conflicts and dispute about water. Fortunately, most of the conflicts have ended up in the courts instead of the battlefields. This chapter is devoted to this precious resource that sustains our planet and its living things.
Chapter outline:

1. Properties of water
    a. hydrogen bonding
    b. Physical state of water
    c. Heat capacity
    d. Heat of Vaporization
    e. Universal Solvent
    f. Cohesion and Adhesion

2. Global Water Distribution and Use
3. The Hydrologic Cycle
4. Components of the Hydrologic Cycle
    a. Atmosphere and precipitation
    b. Rivers and Streams
    c. Lakes, Ponds and reservoirs
    d. Wetlands
    e. Oceans
    f. Groundwater
5. Water Scarcity and Shortage
6. Water Pollution and Quality
    a. Types of water pollution
    b. Sources of water pollution
7. Water Management
    a. Water pollution control
    b. Watershed Management
    c. Regulations

Water

Water is an important commodity for life on Earth and is something we all need in our daily activities. It is referred to by many people as the "essence of life", "blue gold" and "more precious than oil". What makes water so important is its unique and special properties. These special properties of water include water's high heat capacity and heat of vaporization, its ability

to dissolve numerous polar molecules, its cohesive and adhesive properties, and its dissociation into ions that leads to the generation of pH. Understanding these characteristics helps us understand and appreciate its importance in maintaining life on Earth. Before we discuss these properties, we will review the molecular structure of water, which gives rise to these special properties.

Properties of Water

A water molecule is composed of one oxygen and two hydrogen atoms that are joined together by **polar covalent** bonds. Covalent mean that the atoms share electrons, instead of completely giving up electrons to one another. **Polar** means that the electrons are not shared equally. These polar covalent bonds (**Figure 8.1**), along with the molecular shape, cause the water molecule to have a slightly positive charge on the hydrogen end and a slightly negative charge on the oxygen side. Water's charges are generated because oxygen is more electronegative than hydrogen, making it more likely that a shared electron would be found near the oxygen nucleus than the hydrogen nucleus, thus generating the partial negative charge near the oxygen. This gives water molecules their properties of attraction.

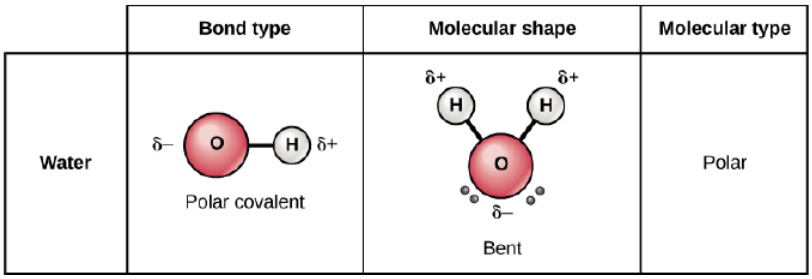


Figure 8.1: Polarity of the water molecule due to the uneven distribution of electrons in its covalent bond. C (From OpenStax Concepts of Biology text)

Hydrogen Bonds

Due to water's polarity, each water molecule attracts other water molecules as oppositely charged ends of the molecules attract each other. When this happens, a weak interaction occurs between the *positive* hydrogen end from one molecule and the *negative* oxygen end of another molecule. This interaction is called a **hydrogen bond**. This hydrogen bonding contributes to the following water's unique properties.

1. Water is the universal solvent
2. Exists in nature as a solid, liquid, and gas
3. The density of ice is less than liquid water
4. Water has a high surface tension
5. Water has a high heat capacity
6. Water exists as a liquid at room temperature

It is important to note here that even we are only focusing on water in this text book, hydrogen bonding also occurs in other substances that have polar molecules**.**

Physical State of Water on Earth

Water on Earth can naturally exist as either solid, liquid or gas depending on the prevailing temperature and pressure conditions. The formation of hydrogen bonds (described above) is an important quality of liquid water that is crucial to life as we know it on Earth. As water molecules make hydrogen bonds with each other, liquid water takes on some unique physical and chemical characteristics when compared to other liquids. In liquid water, hydrogen bonds are constantly being formed and broken as the water molecules slide past each other. The energy of the moving water molecules (kinetic energy) is responsible for breaking the bonds. When heat is added to water (increasing temperature), the kinetic energy of the molecules goes up and more bonds are broken. As more heat is added to boiling water, the higher kinetic energy of the water molecules causes the hydrogen bonds to break completely and allow them to escape into the air as water vapor. On the other hand, when the temperature of water is reduced and water freezes, the water molecules form a crystalline structure maintained by hydrogen bonding (since there isn't enough energy to break the hydrogen bonds). The crystalline structure, ice, has a more open structure than the liquid form of water. The open structure of ice (Figure 8.2) makes ice less dense than liquid water, a phenomenon not seen in the solidification of other liquids.

The lower density of ice, illustrated in Figure 8.2, causes it to float at the surface of liquid water, such as an iceberg in the ocean or ice cubes in a glass of ice water. In lakes and ponds, ice will form on the surface of water creating an insulating barrier that protects animals and plant life that live in the water from freezing. Without this layer of insulating ice, plants and animals living in the water would freeze in the solid block of ice and not survive. The ice crystals that form upon freezing would rupture the delicate membranes essential for the function of living cells, irreversibly damaging them.

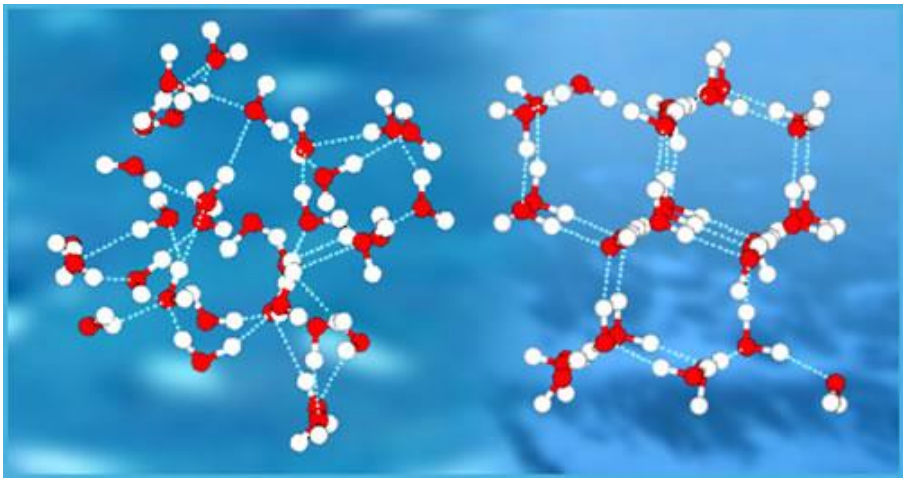


Figure 8.2: Hydrogen bonding makes ice less dense than liquid water. The lattice structure water is more condensed (left structure) than that of ice (right structure). The lattice structure of ice makes it less dense than freely flowing molecules of liquid water, enabling ice to float on liquid water. (Image credit: Lynn Yarris, http://www2.lbl.gov/Science-Articles/Archive/sabl/2005/February/water-solid.html)

High Heat Capacity

Water has the highest **specific heat capacity** of any liquid. Water's high heat capacity is a property caused by hydrogen bonding among the water molecules. **Specific heat** is defined as the amount of heat one gram of a substance must absorb or lose to change its temperature by one degree Celsius. For water, this amount is one **calorie**. It takes water a long time to heat up and a long time to cool down. In fact, the specific heat capacity of water is about five times more than that of sand. This explains why land cools faster than the sea. Due to its high heat capacity, warm

blooded animals use water to disperse heat more evenly and maintain temperature in their bodies: it acts in a similar manner to a car's cooling system, transporting heat from warm places to cool places, causing the body to maintain a more even temperature.

Heat of Vaporization

Water also has a high **heat of vaporization**, the amount of energy required to change one gram of a liquid substance to a gas. A considerable amount of heat energy (586 calories) is required to accomplish this change in water. This process occurs on the surface of water. As liquid water heats up, hydrogen bonding makes it difficult to separate the liquid water molecules from each other, which is required for it to enter the gas phase (steam). Thus, water acts as a heat sink and requires much more heat to boil than liquids such as ethanol, whose hydrogen bonds are weaker. Eventually, as water reaches its boiling point of 100° Celsius (212° Fahrenheit), the heat can break the hydrogen bonds between the water molecules, and the kinetic energy between the water molecules allows them to escape from the liquid as a gas. Even when below its boiling point, water's individual molecules acquire enough energy from other water molecules such that some surface water molecules can escape and vaporize: this process is known as **evaporation**.

Since hydrogen bonds need to be broken for water to evaporate means that a substantial amount of energy is used in the evaporation process. As the water evaporates, energy is taken up by the process, cooling the environment where the evaporation is taking place. In many living organisms, including in humans, the evaporation of sweat, which is 90 percent water, allows the organism to cool so that homeostasis of body temperature can be maintained.

Water is a Solvent

Since water is a polar molecule with slightly positive and slightly negative charges, ions and polar molecules can readily dissolve in it. Water is, therefore, referred to as a **solvent**, because it is capable of dissolving more substances (polar substances) than any other liquid. The charges associated with these molecules will form hydrogen bonds with water, surrounding the particle with water molecules. This is very important as it enables water to dissolve various chemicals and distribute them within living organisms, including taking toxic substances out of living things, and in the environment.

Water's Cohesive and Adhesive Properties

Have you ever filled a glass of water to the very top and then slowly added a few more drops? Before it overflows, the water forms a dome-like shape above the rim of the glass (Figure 8.3)



Figure 8.3. Water in a glass form a dome shape above the glass due to cohesive forces of attraction among water molecules. Photo Credit: Sam Mutiti

This water can stay above the glass because of its **cohesive** properties. In cohesion, water molecules are attracted to each other (because of hydrogen bonding), keeping the molecules together at the liquid-gas (water-air) interface, although there is no more room in the glass. Cohesion allows for the development of **surface tension**, the capacity of a substance to resist rupture when placed under tension or stress. This is also why water forms droplets when placed on a dry surface rather than being flattened out by gravity (**Figure 8.4**)



Figure 8.4. Beading up of water due strong cohesive forces between water molecules (Water USGS, right hand photo credit: J Schmidt; National Park Service).

When a steel needle is placed carefully on water it does not sink even though steel is denser (heavier) than the water. Cohesion and surface tension keep the hydrogen bonds of water molecules intact and support the item floating on the top. It is even possible for an insect to "float" on water if it sits gently without breaking the surface tension, as shown in **Figure 8.5**.



Figure 8.5 The weights of the needle and water strider are pulling the surface downward; at the same time, the surface tension is pulling it up, suspending them on the surface of the water and keeping them from sinking. (Credit: Cory Zanker (left) and Tim Vickers (right)

Another important property of water is **adhesion**, or the attraction between water molecules and other molecules. This attraction is sometimes stronger than water's cohesive forces, especially when water is exposed to charged surfaces such as on the inside of thin glass tubes known as capillary tubes. Adhesion is observed when water "climbs" up the tube placed in a glass of water: notice that the water appears to be higher on the sides of the tube than in the middle. This is because the water molecules are attracted to the charged glass walls of the capillary tube more than they are to each other and, therefore, adhere to it. This type of adhesion is called **capillary action**, and is illustrated in **Figure 8.6**. This process is also involved in the movement of water and nutrients from the soil around the root systems to other parts of plants above the ground.

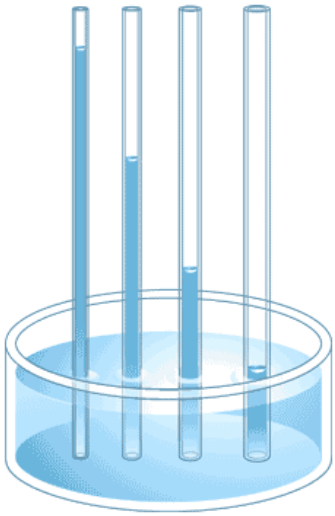


Figure 8.6: Capillary action in a glass tube is caused by the adhesive forces exerted by the internal surface of the glass exceeding the cohesive forces between the water molecules themselves. (Credit: http://moodle.clsd.k12.pa.us/district_videos/Biology/iText/products/0-13-115540-7/ch23/ch23_s5_1.html)

Global Water Distribution and Use

Most of the water on the planet is in oceans and unavailable for human consumption due to its high salinity (**Figure 8.7**).

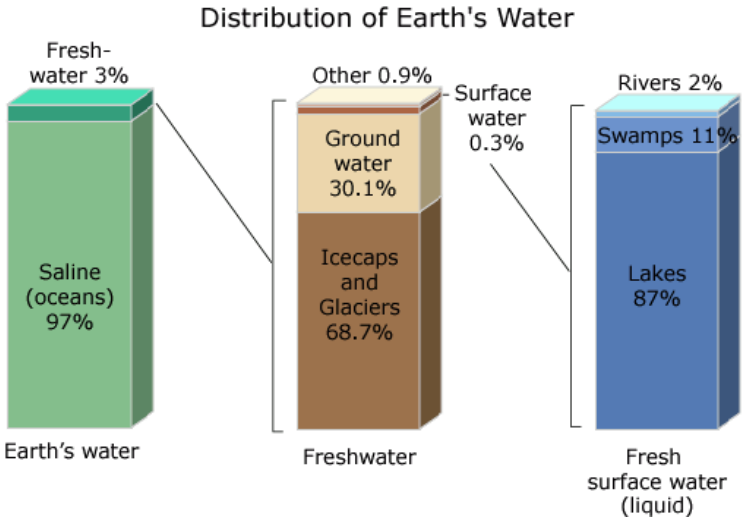


Figure 8.7: Graphical representation of available water: http://water.usgs.gov/edu/earthwherewater.html

Of all the water in the world, only about 0.64% is fresh water that is available for consumption (the other fresh water is locked up in ice). Of this available fresh water, 98.4% is found as groundwater below the surface of the Earth and only 1.4% is surface water in rivers and lakes.

The largest percentage of water withdrawn in the US goes to thermoelectric cooling (**Figure 8.8**). In some countries, such as Egypt, irrigation accounts for over 70% of water withdrawn. Irrigation is water that is applied by a water system to sustain plant growth. Irrigation also includes water that is used for frost protection, application of chemicals, weed control, field preparation, crop cooling, harvesting, dust suppression, and leaching salts from the root zone.

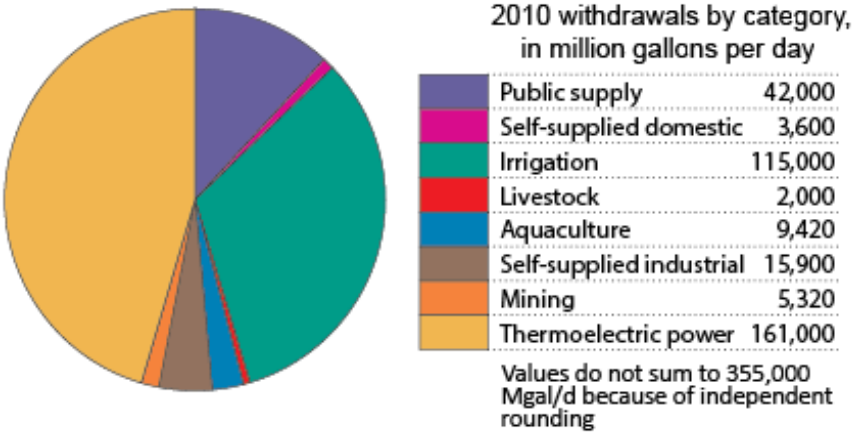


Figure 8.8: Estimated 2010 water withdrawals. Irrigation and thermoelectric power usages account for most water withdrawals. http://water.usgs.gov/watuse/images/category-pages/2010/total-category-pie-2010.png
More water use terminology can be found at: http://water.usgs.gov/watuse/wuglossary.html

The Hydrologic Cycle

The major water reservoirs on Earth are oceans, glaciers, groundwater, rivers, and lakes. Water spends different amounts of time in the various reservoirs. The main factors that control the amount of time water stays in a reservoir are the amount of water in the reservoir and how fast water moves in and out. The hydrologic cycle (water cycle) represents a continuous global cycling of water from one reservoir to another **8.9**.

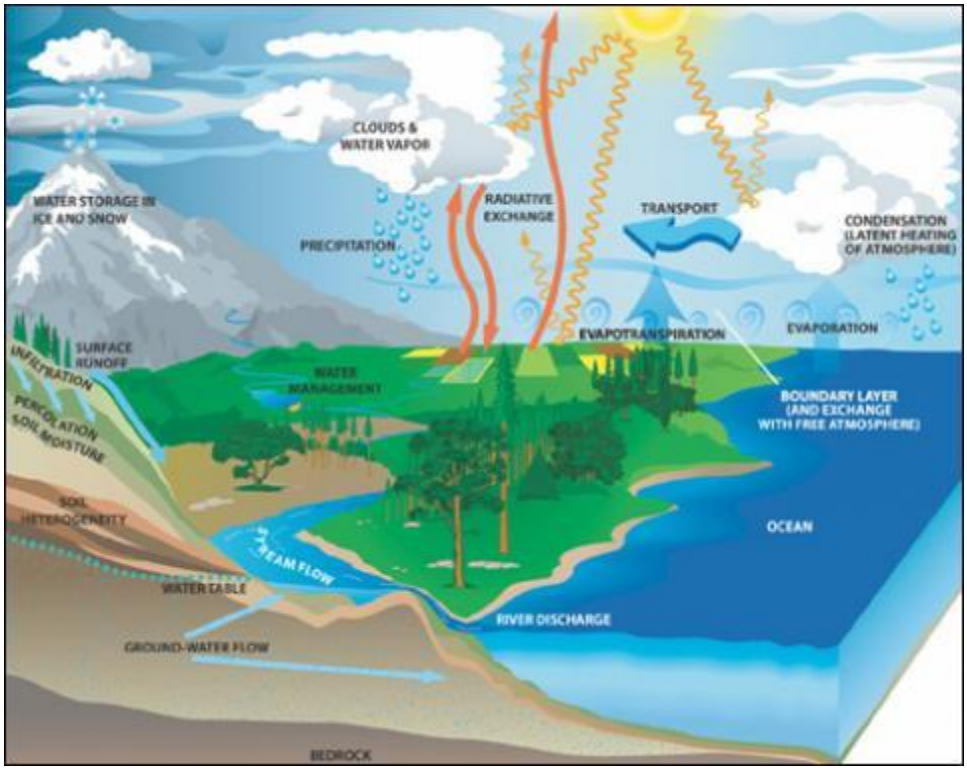


Figure 8.9: The water cycle at the global scale showing water moving through all the major reservoirs, including the ocean reservoir (source https://science.nasa.gov/earth-science/oceanography/ocean-earth-system/ocean-water-cycle).

To gain a deeper appreciation of the water cycle, let us follow a water molecule through the water cycle. Starting in the ocean (an arbitrary starting point) the water molecule can become part of the water that is converted into vapor and enter the atmosphere. Heat energy from the sun, which drives the water cycle, heats water in the oceans and cause evaporation. Evaporation is the process by which water changes from a liquid to a gas or vapor. Evaporation is the primary pathway that water takes from the liquid state back into the water cycle as atmospheric water vapor. Nearly 90% of moisture in the atmosphere comes from evaporation, with the remaining 10% coming from transpiration. **Transpiration** is the process by which moisture is carried through plants from roots to small pores (**stoma**) on the underside of leaves, where it changes to

vapor and is released to the atmosphere. Transpiration is essentially evaporation of water from plant leaves. Rising air currents take the vapor up into the atmosphere, along with water from **evapotranspiration,** which is a combination of water transpired from plants and that evaporated from the soil. The vapor rises into the air where cooler temperatures cause it to condense into clouds. **Condensation** is the process by which water vapor is converted from gaseous state back into liquid state. Clouds might eventually grow bigger and moist enough to release the water molecule in the form of **precipitation**. Precipitation is water falling from the clouds in the atmosphere in form of ice (snow, sleet, hail) or liquid (e.g. rain, drizzle). Precipitation that falls as snow can accumulate as ice caps and glaciers.

Did you know that the largest glacier on Earth is the Severny Island ice cap in the Russian Arctic?

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Precipitation that falls as liquid usually ends up as **surface flow** and **stream flow**. **Surface runoff** is precipitation which travels over the soil surface to the nearest stream channel. **Stream flow** is the movement of water in a natural channel, such as a river. Most precipitation falls directly onto the ocean and returns the water molecule back to restart the journey. This is also true for surface runoff, most of the water eventually returns to the ocean via stream flow. This also returns the water molecule back the ocean to start the journey again.

A portion of the water that falls as precipitation can enter lakes where it can evaporate back into the atmosphere, condense, and fall back as precipitation again. Water in the lake can also be taken up by plants and transpired back into the atmosphere. Some of the water that falls as precipitation can infiltrate into the ground and become part of groundwater. **Infiltration** is the process by which water enters the subsurface by gravitation pull. Some of the water infiltrates into the ground and replenishes **aquifers** (saturated subsurface rock), which store huge amounts of freshwater for long periods of time. Some infiltration stays close to the land surface and can seep back into surface-water bodies (and the ocean) as **groundwater discharge**, and some groundwater finds openings in the land surface and emerges as freshwater **springs.** Plant roots absorb yet more groundwater to end up as evapotranspiration from the leaves. Over time, though, all this water keeps moving and most of it ends up in the ocean.

Components of the Hydrologic Cycle

Most precipitation falls in the form of rain but there are other forms such as snow, hail, and sleet. Once it runs sufficiently, surface water runoff is generated when the ground is saturated or impervious. **Surface water** is a major component of the hydrological cycle and one that we interact with very regularly. It includes lakes, wetlands, stormwater **runoff** (overland flow), ponds, potholes, rivers and streams.

Streams and Rivers

A river forms from water moving from a higher altitude to lower altitude, under the force of gravity. When rain falls on the land, it either evaporates, seeps into the ground or becomes runoff (water running on the surface). When water runs on the land surface it usually converges as it moves towards lower elevation. The converging runoff can concentrate into single channels of conveyance called creeks, stream, or rivers. Usually these start as small rill and rivulets that would join up downhill into larger streams and creeks which can also join up downstream to form even bigger rivers. The streams and rivers that join up to form a larger river are called **tributaries, Figure 8.10**. The land area drained by a river and all its tributaries is called a **watershed** or catchment or river basin

The area adjacent to a river that floods frequently is a called a floodplain. **Floodplains** are areas that rivers use to temporarily store excess water during storm events and frequently contain very fertile soils. This has historically encouraged humans to move into floodplains and use them for agriculture, resulting in a reduction in the capacity of the floodplain to act as temporally storage for excess water during storm events, causing increased damaging flooding downstream. Properly functioning floodplains reduce the negative impacts of floods (by reducing severity of flood), and they assist in filtering stormwater and protecting the water quality of rivers. They also act as areas of recharge for groundwater.



A



B



C

Figure 8.10: River systems. (A) A river with a small tributary (B) A meandering river with a mature floodplain (C) A satellite image of river system with multiple tributaries (Source USGS)

The US has numerous rivers that run throughout the nation's landscape. It is estimated that the US has over 200, 000 rivers with the Mississippi River being the largest by volume despite it only being the second longest. The Missouri River is the longest river in US. Most states have at least one important river. In Georgia, the main rivers are the Flint, Ochlockonee,

Suwannee, Saint Marys, Satilla, Ogeechee, Altamaha, Oconee, Savannah, Chattahoochee, Tallapoosa, Coosa, Ocmulgee and the Tennessee rivers (**Figure 8.11**).

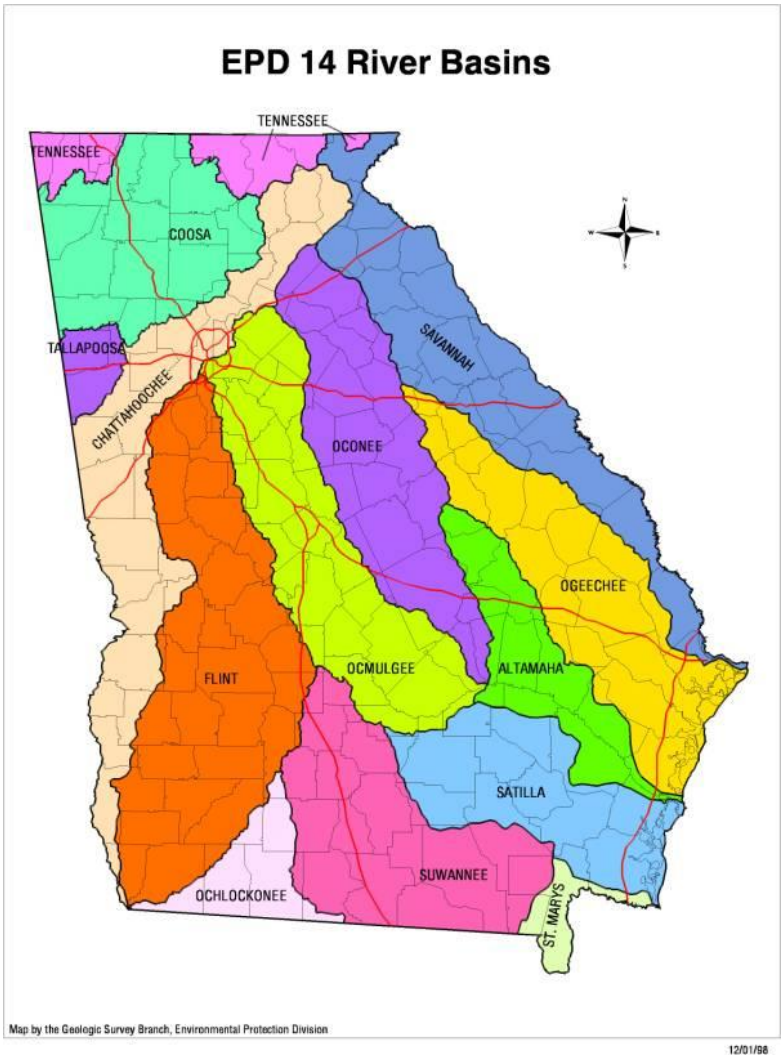


Figure 8.11: Major watershed of Georgia representing the main rivers in the state. (Source Georgia Environmental Protection Division: georgiaadoptastream.com)

These rivers are very important for supplying water to the cities and populations of the states. The rivers also contain important biological communities and provide opportunities for recreation such as swimming, fishing, and white water rafting. Rivers are so important and largely control settlement patterns all over the world. Major cities, communities, factories, industries, and power stations are located along rivers. It is, therefore, very important to protect the quality and integrity of rivers all over the world.

Unfortunately, most of the rivers in the world are too polluted to support certain human activities, especially swimming, fishing, and drinking. Close to half of the rivers in the US have been deemed too polluted to support swimming and fishing. A lot of the rivers have also been channelized, dredged, or impounded by dams which have ruined their ability to support a lot of human and biological activities. It is estimated that over 600, 000 river miles have been dammed in the US. Benefits of dams to humans include providing a source of water (reservoirs and farms ponds), recreation waters and reducing local flooding. On the other side, dams can also have negative impacts on people and the environment. They can lead to increased severe flooding downstream of the dam, especially during high rain events.

The impoundments can trap stream sediments resulting in reduced sediment supply downstream as well as increased deposition behind the dam. This shift in sediments flow can disrupt and damage aquatic habitats and can increase downstream stream erosion due to lack of sediment supply. The impoundments can also prevent certain aquatic organisms from migrating either upstream or downstream, therefore reducing their range and abilities to survive

environmental changes as well cutting them off from spawning areas. Construction of dams can also result in displacement of the local people and loss of traditional lands and cultural history. Reservoirs and ponds usually form behind these impoundments.

Lakes, Reservoirs and ponds: If water flows to a place that is surrounded by higher land on all sides, a lake will form (**Figure 8.12**). A lake, pond or reservoir is a body of standing water on the land surface. When people build dams to stop rivers from flowing, the lakes that form are called reservoirs. It is estimated that over 300 million water bodies in the world are lakes, reservoirs, and ponds. Most of the Earth's lakes (about 60%) are found in Canada. Even though lakes and rivers contain less than 1% of the Earths water, the US gets over two thirds (70%) of its water (for drinking, industry, irrigation, and hydroelectric power generation) from lakes and reservoirs. Lakes are also the cornerstone of the US's freshwater fishing industry and are the backbone of the nation's state tourism industries and inland water recreational activities. (http://water.epa.gov/type/lakes/)



Figure 8.12: Lake Sinclair in Baldwin and Putnam counties (Photo Credits: GCSU Hydrology Research lab)

Wetland: A **wetland** is an area which is home to standing water for notable parts of the year, has saturated soils for a large part of the year and has plants that require large amounts of water to survive. Wetlands include swamps, marshes, and bogs. Wetlands are identified using three characteristics: soils (water-saturated soils are present), hydrology (shallow water table) and vegetation (wetland plants that are adapted to areas that are saturated with water for long periods of time). Wetlands are very important areas of biological diversity and productivity. These are also important areas where geochemical and biological cycles/ processes are consistently taking place. For instance, wetlands are considered as areas of significant carbon sequestration (storage), which impacts global climate change. They also act as filters for storm-water runoff before it enters rivers and lakes.

Oceans

As you have probably already guessed, oceans are an important component of the hydrologic cycle because they store majority of all water on Earth (about 95%). Most of the major rivers drain into them. The five oceans covering the surface of the Earth are the Atlantic, Indian, Pacific, Arctic and the Southern Ocean (**Figure 8.13**).

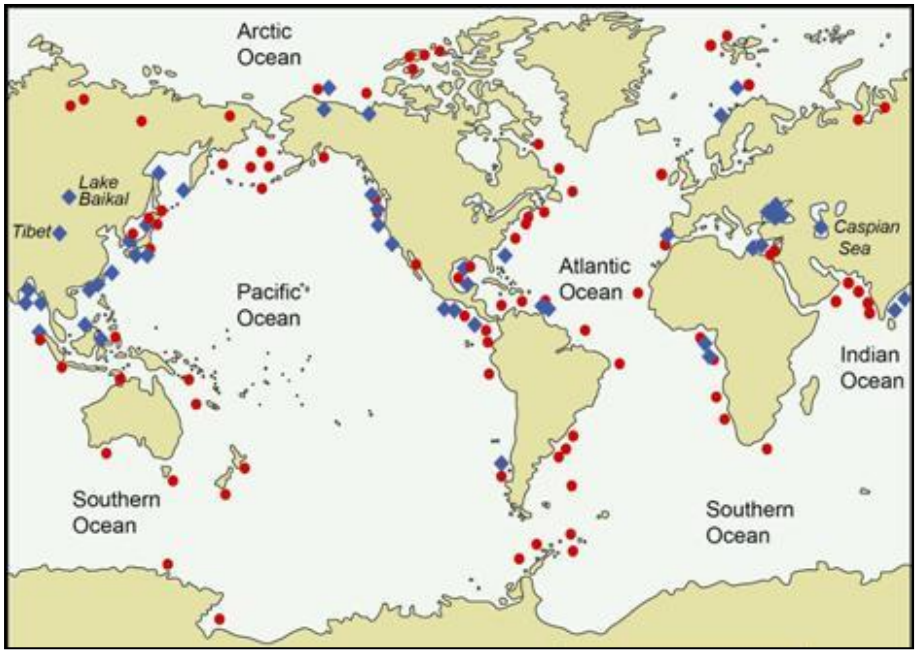


Figure 8.13: The five oceans found on planet Earth. The Pacific Ocean is the largest. Source: https://woodshole.er.usgs.gov/project-pages/hydrates/primer.html

Approximately 90 % of the water that is evaporated into the hydrologic cycle comes from the ocean. Oceans are an important and large part of the hydrologic cycle, with lots biological diversity and many landforms. *Did you know that the average depth of the oceans is about 3.6 km with a maximum depth that can exceed 10 kilometers in areas known as ocean trenches?* The ocean is also home to many forms of life uniquely adapted to survive in this habitat. Unfortunately, humans have degraded the oceans and their life through pollution, overfishing, carbon dioxide acidification and resource exploitation. **Figure 8.14** shows a couple of examples of human impacts on the ocean environment.



From NOAA Libraries

Figure 8.14: Trash washed up on the beach (A) and seal tangles up and being struggled by plastic trash in the ocean (B).

Also watch the video from the Habitable Planet: Oceans Video
vhttp://www.learner.org/courses/envsci/unit/text.php?unit=3&secNum=1

Groundwater

Storage and Flow

Almost 99% of the available fresh water is found below the surface as groundwater. Groundwater is not created by some mysterious processes below ground, but is part of the recycled water in the hydrologic cycle. When precipitation falls, some of the water runs off on the surface while some infiltrates into the ground. Groundwater is replenished when water moves from the surface, through unsaturated rocks or sediment (**unsaturated**), all the way down the saturated parts (**saturated zone**) in a process called infiltration and becomes groundwater (**Figure 8.15**). The top of the saturated portion is called the **water table**, which is the boundary between saturated and unsaturated zone.

Groundwater is found in **aquifers**, which are bodies of rock or sediment that store (and yield) large amounts of usable water in their pores. Aquifer productivity is controlled by **porosity** and **permeability**. **Porosity** is the percentage of open space in a rock or sediment body. **Permeability** is the ability of subsurface material to transmit fluids. Groundwater is found in the saturated zone of a rock body where all pores are filled with water. An important concept is that surface water always moves from higher elevation to lower elevation while groundwater always moves from higher energy (hydraulic head) to lower energy.

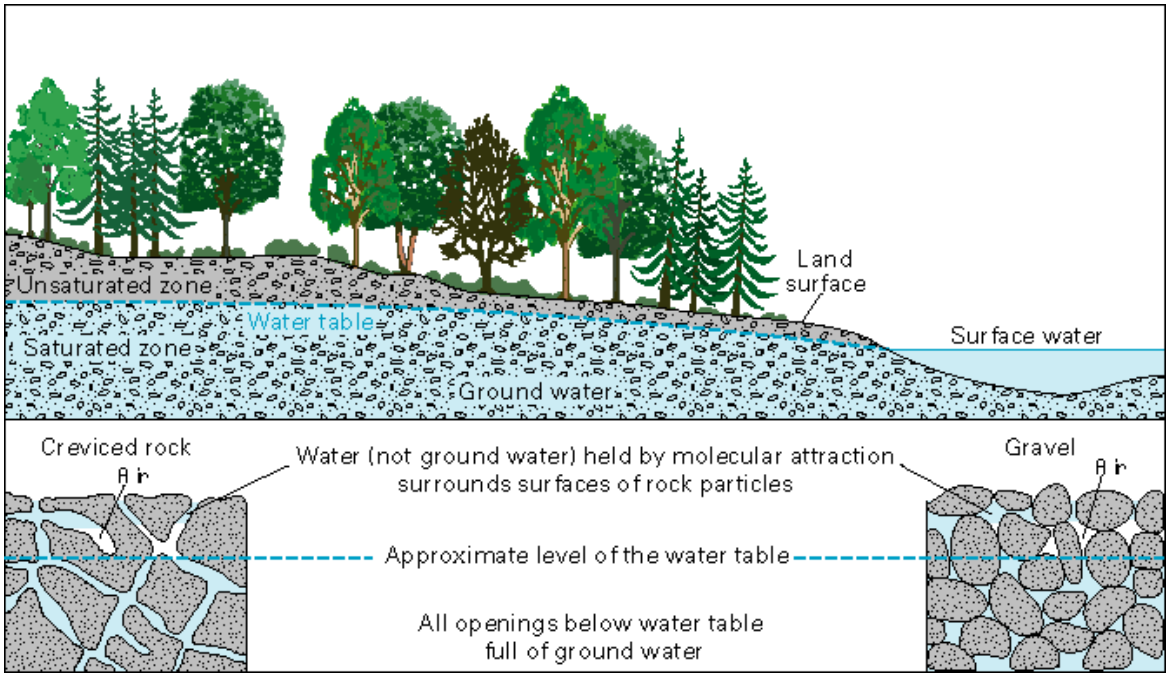
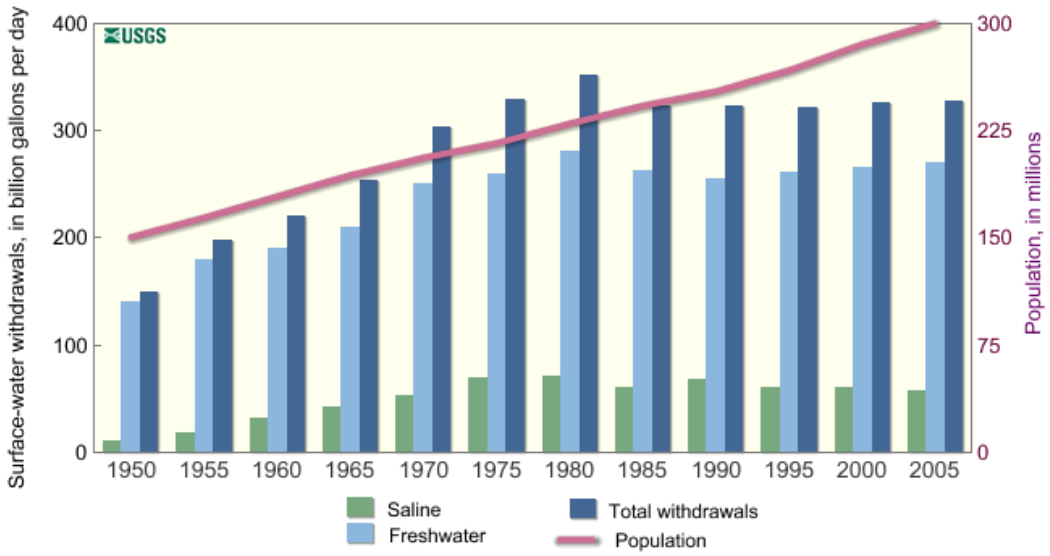


Figure 8.15: Model of groundwater system showing the different components of an unconfined groundwater system: http://water.usgs.gov/edu/earthgwaquifer.html

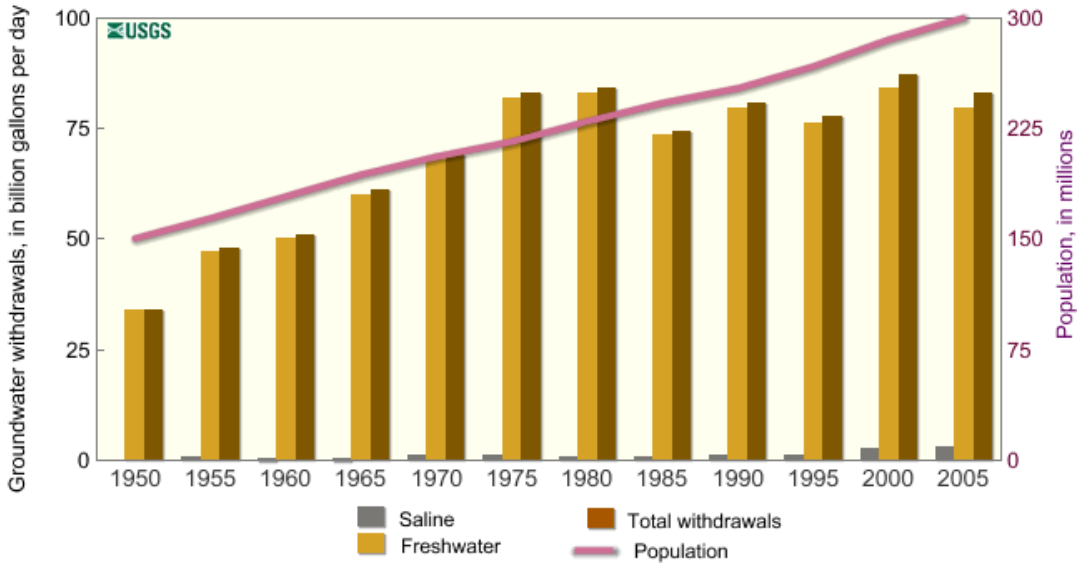
Groundwater will continue to flow until it emerges as a spring, or discharges into surface water bodies on the land or in the ocean. To utilize groundwater, we drill holes (wells) into the ground and pump the water out.

Water Scarcity and Shortage

Water has been identified as one of the major environmental crisis facing the world today. More than one billion people in the world lack access to clean drinking water. The demand for water has grown at a very fast pace in response to the rate of global population growth. **Figures 8.16, and 8.17** illustrate this change in water use over time. It is predicted that over the next two decades, the average supply of water per person will drop by a third.



A)



B)

Figure 8.16: Trends in fresh and saline water withdrawals in response to population growth (A) surface water withdrawals (B) Groundwater withdrawal trends: http://water.usgs.gov/edu/wugw.html

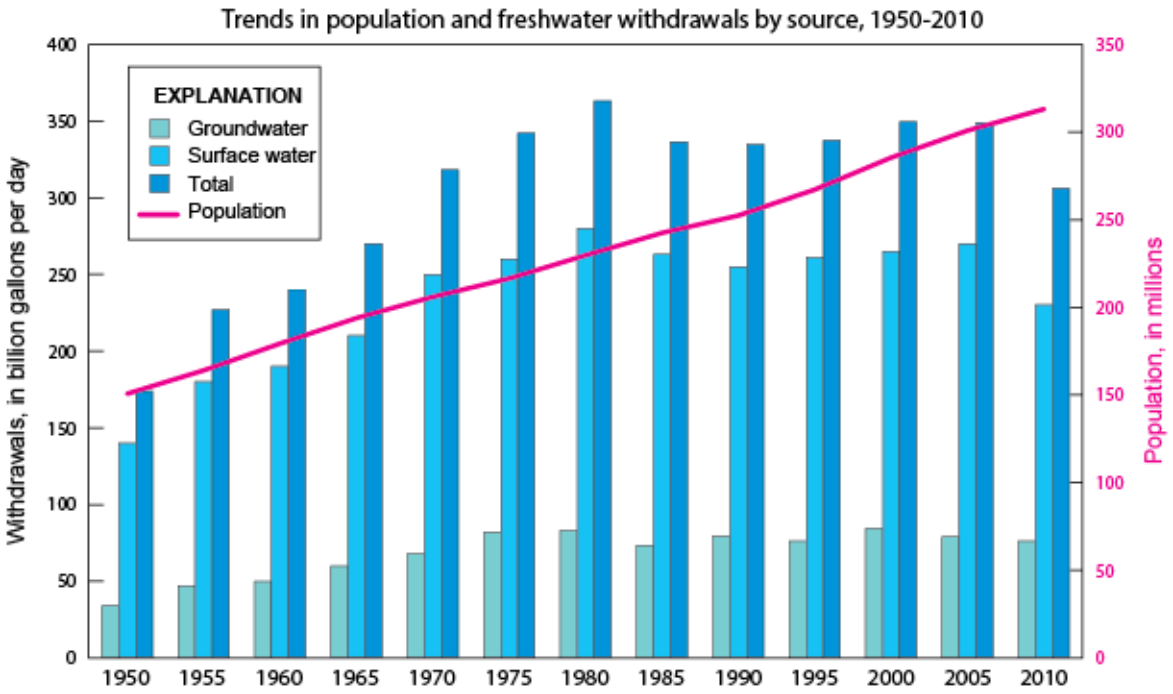


Figure 8.17: Both groundwater and surface water withdrawals had increased over time until 1980 when the withdrawals peaked and stabilized.

Water Scarcity and Availability

There is enough fresh water on Earth to supply every human being with enough drinking water. The main problem we face with regards to water is that it is unevenly distributed, polluted, mismanaged and wasted. Tony Allan, the author of Virtual Water, asserts that water follows money. This refers to the fact that rich countries and societies with money and affluence have more access to safe drinking water even when they live in regions without much water. It also means that areas with large supplies of water can still have water scarcity if they lack the financial resources to build the infrastructure to supply people with safe clean drinking water. Water scarcity is caused by the demand for water being greater than the supply. Scarcity can be defined as either **physical scarcity** or **economic scarcity**.

Physical water scarcity is a situation where there is an actual shortage of water, regardless of quality or infrastructure. It is estimated that about 1.2 million people around the world are experiencing physical water scarcity. **Economic scarcity** is a condition where countries lack the financial resources and/or infrastructure to supply their citizens with reliable safe drinking water. About 1.6 billion people are experiencing economic water shortage; most of them live in less industrialized countries. For a lot of places in the world, scarcity is a transient condition that can be reduced or eliminated by installing the right infrastructure. The major problem in less industrialized countries is the lack of political, financial, and physical structures to provide water to everyone. A few rich people in these countries get the clean water while the majority of the people who cannot afford to pay for it are left out. Examples of such communities include many villages in Africa, Asia, and South America. **Figure 8.18** shows communities in south east Kenya that are experiencing severe water shortages primarily due to lack of infrastructure. Women in these communities must walk long distances to get untreated and contaminated water for drinking and other household needs.



Figure 8.18: Communities in southeast Kenya without ready access to safe drinking water. (A) Groundwater in the area is too salty for consumption. B) Maasai women in Amboseli National Park collecting water from a wetland. (C) Women in Magwede village in SE Kenya walking long distances to get water from a Kiosk. D) Children collecting water in Bungule Village from a water kiosk that is only open for about an hour every day. *Photo credit: Jonathan Levy, Sam Mutiti and Christine Mutiti*

Water Quality (pollution)

Water pollution is a major problem facing many of our surface water and groundwater sources. Contamination can both be natural due to geologic or meteorological events and anthropogenic (human causes). Human sources of contamination can be categorized as either point source or nonpoint source. **Point-source pollution** is water pollution coming from a single point, such as a sewage-outflow pipe. **Non-point source (NPS) pollution** is pollution discharged over a wide land area such as agricultural runoff and urban stormwater runoff, not from one specific location. Non-point source pollution contamination occurs when rainwater, snowmelt, or

irrigation washes off plowed fields, city streets, or suburban backyards. As this runoff moves across the land surface, it picks up soil particles and pollutants, such as nutrients and pesticides.

Types of Water Pollution

Contamination of water resources comes in the form of chemical, biological, and physical pollution. **Chemical pollution** includes things such as toxic metals, organic compounds, acidic waters from mining activities and industry, pharmaceuticals and many other chemical compounds from industries and wastewater treatment plants. Another form of chemical pollution is radioactive waste which has a significant potential to cause harm to living things. Most of the radioactive pollution comes from agricultural practices such as tobacco farming, where radioactive phosphate fertilizer is used. **Physical pollution** includes sediment pollution, trash thrown in the water bodies, thermal and other suspended load. Temperature typically affects the metabolism of aquatic fauna in a negative way and can encourage eutrophication. **Biological pollution** usually refers to pathogenic bacteria, viruses, and parasitic protozoa. Common pathogenic microbes introduced into natural water bodies are pathogens from untreated sewage or surface runoff from intensive livestock grazing. Biological pollution is a common cause of illness and death in less industrialized countries where population density, water scarcity and inadequate sewage treatment combine to cause widespread parasitic and bacterial diseases.

Sources of water pollution

Most of the common inorganic chemical water pollutants are produced by non-point sources, mainly intensive agriculture, and high-density urban areas. Specific inorganic chemicals and their major sources are: ammonium nitrate and a host of related phosphate and nitrogen compounds used in agricultural fertilizers; heavy metals (present in urban runoff and mine tailings area runoff). However, some inorganic contaminants such as chlorine and related derivatives are produced from point sources, ironically employed in water treatment facilities. Moreover, some of the large dischargers of heavy metals to aquatic environments are fixed point industrial plants.

High concentrations of nitrogen (N) and phosphorus (P) in water can cause **eutrophication**. You are seeing this whenever you notice the greenish tint to the water in our local streams and rivers during low-flow times, or if you have ever seen a green farm pond. These nutrients are primarily coming from:

- treated wastewater (laden with P and N) being dumped into the river from sewage plants,
- agricultural areas where farmers allow livestock direct access to the stream, and
- agricultural areas where there is intense fertilizer application, and from landscapes (homes, gardens, golf courses) with fertilizer runoff.

The N and P act as fertilizers in the water and promote algae blooms. As the algae dies, it is decomposed by aerobic bacteria in the water. These bacteria use up the oxygen in the water and the low dissolved oxygen (DO) levels can results in “fish kills” where large numbers of fish, and other aquatic life, die because of suffocation. The dead zone in the Gulf of Mexico is a huge area of low DO that has a large negative impact on the fishing industry along the Gulf Coast near the mouth of the Mississippi River. The dead zone occurs annually when fertilizers, from farm fields in the Midwest, wash down the Mississippi river.

Improper storage and use of automotive fluids produce common organic chemicals causing water pollution. These chemicals include methanol and ethanol (present in wiper fluid); gasoline and oil compounds such as octane, nonane (overfilling of gasoline tanks); most of these are considered non-point sources since their pathway to watercourses is mainly overland flow.

However, leaking underground and above ground storage tanks can be considered point sources for some of these chemicals, and even more toxic organic compounds such as perchloroethylene. Grease and fats (such as lubrication and restaurant effluent) can be either point or non-point sources depending upon whether the restaurant releases grease into the wastewater collection system (point source) or disposes of such organics on the exterior ground surface or transports to large landfills.

The most significant **physical pollutant** is excess sediment in runoff from agricultural plots, clear-cut forests, improperly graded slopes, urban streets, and other poorly managed lands, especially when steep slopes or lands near streams are involved. Other **physical pollutants** include a variety of plastic refuse products such as packaging materials; the most pernicious of these items are ring shaped objects that can trap or strangle fish and other aquatic fauna (**Figure 8.14**). Other common physical objects are timber slash debris, waste paper and cardboard. Finally, power plants and other industrial facilities that use natural water bodies for cooling are the main sources of thermal pollution.

Groundwater can also become contaminated from both natural and anthropogenic sources of pollution. Naturally occurring contaminants are present in the rocks and sediments. As groundwater flows through sediments, metals such as iron and manganese are dissolved and may later be found in high concentrations in the water. Industrial discharges, urban activities, agriculture, groundwater withdrawal, and disposal of waste all can affect groundwater quality. Contaminants from leaking fuel tanks or fuel or toxic chemical spills may enter the groundwater and contaminate the aquifer. Pesticides and fertilizers applied to lawns and crops can accumulate and migrate to the water table.

Leakage from septic tanks and/or waste-disposal sites also can contaminate ground water. A septic tank can introduce bacteria to the water, and pesticides and fertilizers that seep into farmed soil can eventually end up in water drawn from a well. Or, a well might have been placed in land that was once used as a garbage or chemical dump site.

Water Management

Pollution control begins with testing and monitoring of water quality. Water quality is usually monitored using easy to measure indicators such as pH, specific conductance (commonly referred to as conductivity), temperature, fecal and total coliform bacteria, dissolved oxygen, macroinvertebrates, and algae. Polluted sites typically have reduced DO levels, lower pH (more acidic), higher nutrient levels, more bacteria, and higher temperatures compared to less impacted or pristine sites.

Non-point source control relates mostly to land management practices in the fields of agriculture, mining and urban design and sanitation. Agricultural practices leading to the greatest improvement of sediment control include: contour grading, avoidance of bare soils in rainy and windy conditions, polyculture farming resulting in greater vegetative cover, and increasing fallow periods. Minimization of fertilizer, pesticide and herbicide runoff is best accomplished by reducing the quantities of these materials, as well as applying fertilizers during periods of low precipitation. Other techniques include avoiding of highly water soluble pesticides and herbicides, and use of materials that have the most rapid decay times to benign substances.

The main water pollutants associated with mines and quarries are aqueous slurries of minute rock particles, which result from rainfall scouring exposed soils and also from rock washing and grading activities. Runoff from metal mines and ore recovery plants is typically contaminated by the minerals present in the native rock formations. Control of this runoff is

chiefly achieved by preventing rapid runoff and designing mining operations that avoid tailings either on steep slopes or near streams.

In the case of urban stormwater control, good urban planning and design can minimize stormwater runoff. By reducing impermeable surfaces (pavement that doesn't allow water through), then cities can reduce the amount of surface water runoff the carries pollutants into surface water and causes flooding. Additionally, the use of native plant and xeriscape techniques reduces water use and water runoff, and minimizes the need for pesticides and nutrients. Regarding street maintenance, a periodic use of street sweeping can reduce the sediment, chemical and rubbish load into the storm sewer system

The two common approaches to water management fall under either voluntary programs or the regulatory program. The regulatory approach has been very successful in controlling and reducing point source pollution, which was the focus of regulations when they were first introduced. Voluntary programs, together with new amendments to regulations, have had great success in increasing conservation and reducing diffuse nonpoint source pollution. One of the most widely used voluntary programs is **Watershed Management** while the regulatory approach is centered on the Clean Water Act (CWA).

Watershed Management

The watershed management approach recognizes that water contamination problems are complex and not localized to a section of a river. Water pollution problems are caused by multiple activities within the watershed and, therefore, require holistic approaches in the entire **watershed**. A **watershed** (drainage basin or catchment) is an area of land that drains to a single outlet and is separated from other watersheds by a drainage divide. Rainfall that falls in a watershed will generate runoff (if not trapped or infiltrated into groundwater) to that watershed's outlet. Topographic elevation is used to define a watershed boundary. A focal point of water management plans is the Best Management Practices (BMPs) section. BMPs are designed to consider all of the various uses of water, maximize conservation and minimize pollution.

The regulatory approach

Water management through policy and laws seeks to clean up polluted water, prevent further pollution and apply punitive measures for polluters. In the US water-related regulations go as far back as 1899 with the Rivers and Harbors Act, also known as the Refuse Act that prohibited the dumping of solid waste and obstruction of waterways. This regulation, however, did not include waste flowing from streets and sewers. In 1948 another regulation, the Federal Water Pollution Act (which is the basis of the Clean Water Act) was enacted. This regulation covered contamination from sewage outfalls. It was created to reduce contamination of both interstate groundwater and surface waters. Through this regulation funding was made available to states and local governments for water quality management.

One of the major water-related regulations in the US is the Clean Water Act (CWA) of 1972. The regulation was very comprehensive with lots of programs and empowered the Environmental Protection Agency (EPA) to create goals, and objective laws for its implementation. The legislation has programs for both point and nonpoint source pollution. One other major piece of regulation governing water was the 1974 Safe Drinking Water Act (SDWA).

In 1974, amended in 1986, the SDWA was enacted to establish standards for many chemical constituents for public water supplied by public water agencies. In the regulations, maximum contaminant level goals (MCLG), which are non-enforceable and maximum

contaminant levels (MCLs) that are enforceable where created. MCLG are what would be ideal and desirable while MCL are what should be attained in any drinking water supplied by a public municipal agency. For any carcinogen, the MCLG is 0 even though many contaminants have MCLs and detection limits in the parts per billion (ppb) range. Some of them (e.g. dioxin) have MCLs in the parts per trillion (ppt). To give you a sense of how small this ppt is, it is the same as 0.4 mm divided by the distance to the moon.

A Closer Look at the Clean Water Act

The 1972 Clean Water Acts was an overhaul of the 1948 Federal Pollution Control Act. The current regulation includes numerous programs for water quality improvement and protection. The EPA works with its federal, state and tribal regulatory partners to monitor and ensure compliance with clean water laws and regulations in order to protect human health and the environment. The Clean Water Act is the primary federal law governing water pollution. One of the objectives of the CWA was to restore and maintain the integrity of the nation's physical, chemical, and biological waters quality. The ultimate goals of the act are to establish zero pollutant discharge, as well as fishable & swimmable waters in the country. One main component of the CWA is regulations on industrial and municipal discharges into navigable US waters. The act is designed to be a partnership between states and the federal government. The federal government sets the agenda and standards while the state carries out the implementation of the law. States also have the power to set standards that are more stringent than the federal standards if needed. Under the CWA, discharge into US waters is only legal if authorized by a permit. Perpetrators of the law can be punished using administrative, civil, or criminal charges. The second component of the act is providing funding for constructing municipal waste water treatment plants and other projects to improve water quality (Title II and Title VI).

The act covers both point sources (discharge from sources such as pipes) and nonpoint sources (pollution from diffuse sources such as stormwater runoff). Point sources are explicitly covered under section 402, National Pollutant Discharge Elimination System (NPDES). This section requires industries and municipalities to get permits from the EPA before discharging into US waters. The permits require the use of control technology to reduce and prevent pollution.

Water in Crisis (case studies)

- You instructor will assign you a specific case study for the course if needed.

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8.G. **Discussion and Approval of Changes to Governing Board Policies reviewed August 11, 2026: BEDB, CBA, DJ, DJE, IHA, IHB-R, IKE-RB, IKF, JF-R, JFAA-R, JFAB-R, JFABC-R, JFABD-RB, JFABDA-RB, new Regulation JFB-RB, JJAB, Regulation JR-R, KFA**

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POLICY SERVICES
ADVISORY

Volume 38, Number 3 **July 2026**

Policy Advisory No. 1047 ..... Policy BEDB — Agenda

Policy Advisory No. 1048 ..... Policy CBA — Qualifications and Duties of The Superintendent

Policy Advisory No. 1049 ..... Policy DJ —Purchasing Ethics

Policy Advisory No. 1050 .....Policy DJE — Bidding / Purchasing Procedures

Policy Advisory No. 1051 ..... Policy IHA — Basic Instructional Program

Policy Advisory No. 1052 .....Regulation IHB-R — Special Instructional Programs

Policy Advisory No. 1053 ..... Regulation IKE-RB — Promotion and Retention of Students

Policy Advisory No. 1054 ..... Policy IKF — Graduation Requirements

Policy Advisory No. 1055 .....***NEW*** Regulation JF-R — Student Admissions

Policy Advisory No. 1056 .....***NEW*** Regulation JFAA-R — Admission of Resident Students

Policy Advisory No. 1057 ..... ***NEW*** Regulation JFAB-R — Tuition / Admission of Nonresident Students

Policy Advisory No. 1058 ..... ***NEW*** Regulation JFABC-R — Admission of Transfer Students

Policy Advisory No. 1059 ..... ***NEW*** Regulation JFABD-RB — Admission of Homeless Students

Policy Advisory No. 1060 .....***NEW*** Regulation JFABDA-RB — Admission of Students in Foster Care

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Policy Advisory No. 1061 ..... ***NEW*** Regulation JFB-RB — Open Enrollment

Policy Advisory No. 1062 ..... Policy JJAB — Limited Open / Closed Forum

Policy Advisory No. 1063 ..... Regulation JR-R — Student Records

Policy Advisory No. 1064 ..... Policy KFA — Public Conduct on School Property

POLICY ADVISORY DISCUSSION

Summary

The following Policy Advisories reflect legislation enacted during the Fifty-seventh Legislature, Second Regular Session, which convened in January 2026 and adjourned sine die on June 13, 2026. The general effective date for these bills is September 12, 2026, unless otherwise specified.

Policy Advisory Discussion

Policy Advisory No. 1047 **Policy BEDB — Agenda**

This revision reflects the requirements of Chapter 62, HB 2876, amending Arizona's Open Meeting Law. The legislation prohibits a public body from placing a proposal to impose or increase a tax rate, assessment, or fee on a consent agenda. It also provides that any matter discussed in executive session that requires a final vote or decision by the Governing Board must be placed on the regular agenda and may not be included on the consent agenda. These changes reinforce the Open Meeting Law requirement that significant matters requiring Board action be considered as individual agenda items rather than as part of a consent agenda.

Policy Advisory No. 1048 **Policy CBA — Qualifications and Duties of The Superintendent**

This revision reflects the requirements of Chapter 58, HB 2370, amending A.R.S. 15-341. The policy now provides that if the District has a weapons detection system at a school operated by the District, the Governing Board may authorize the Superintendent to modify the system without prior Governing Board approval. The policy also incorporates the statutory requirements that the Superintendent report each modification to the Governing Board within twenty-four (24) hours and that no other person may be authorized to modify the system without prior Governing Board approval.

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Policy Advisory No. 1049 Policy DJ —Purchasing Ethics

This revision incorporates the guidance in the Arizona Auditor General's Uniform System of Financial Records (USFR) regarding the approval and documentation of food and beverage purchases made with public monies.

Although A.R.S. 15-342(39) authorizes Governing Boards to provide food and beverages at District events, including official school functions and trainings, the updated USFR provides guidance indicating that Governing Boards are responsible for approving such purchases in advance or, alternatively, adopting a sufficiently detailed policy or resolution delegating approval authority. The added language incorporates the USFR's recommended process for advance Governing Board approval of individual food and beverage purchases, including documentation of the approved expenditure, funding source, public purpose, District benefit, and compliance with applicable law and funding restrictions.

Districts choosing to authorize food and beverage purchases through a standing policy or resolution rather than individual Governing Board approval should ensure their local policy or resolution includes the specific parameters outlined in the USFR.

Policy Advisory No. 1050 Policy DJE — Bidding / Purchasing Procedures

This revision reflects the 2027 Uniform System of Financial Records (USFR) update increasing the threshold for written price quotations from ten thousand dollars ($10,000) to fifteen thousand dollars ($15,000). The policy now provides that purchases of at least fifteen thousand dollars ($15,000) and less than one hundred thousand dollars ($100,000) require written price quotations from at least three (3) vendors.

Policy Advisory No. 1051 Policy IHA — Basic Instructional Program

This revision reflects the requirements of Chapter 92, HB 2423, amending A.R.S. 15-708. If an advanced mathematics course is available, the policy now provides for the automatic enrollment of qualifying students entering grades six (6), seven (7), or eight (8) in the next advanced mathematics course, unless the student's parent objects. The policy also incorporates the statutory requirement that the District notify the student's parent of the purpose and goals of the automatic enrollment and provide instructions for objecting to the placement.

Policy Advisory No. 1052 Regulation IHB-R — Special Instructional Programs

ASBA previously notified districts of this statutory change in a 2025 Policy Alert following the enactment of Chapter 196 (HB 2170). This revision incorporates that requirement into the model regulation by providing that when a pupil is determined to need special education and related services because of a specific learning disability, the pupil's Individualized

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Education Program (IEP) must indicate whether the pupil has been diagnosed with dyslexia, as required by A.R.S. 15-763.

Policy Advisory No. 1053 Regulation IKE-RB — Promotion and Retention of Students

This revision reflects the requirements of Chapter 75, HB 2032, amending A.R.S. 15-701. The regulation has been updated to align with the revised statutory promotion requirements for third-grade students by requiring that students who do not demonstrate sufficient reading skills, as established by the State Board of Education, not be promoted to the fourth grade. The regulation also incorporates the statutory requirement that a student who is not retained and whose statewide assessment results subsequently demonstrate insufficient reading skills receive evidence-based intervention and remedial strategies.

Policy Advisory No. 1054 Policy IKF — Graduation Requirements

This revision reflects the requirements of Chapter 117, HB 2895, establishing A.R.S. 15-701.05. The policy now provides that if the State Board of Education or the District includes a world language requirement in the minimum course of study for high school graduation, a student may satisfy that requirement by demonstrating proficiency in a Native American language. The policy also clarifies that the District is not required to offer a Native American language course.

Policy Advisory No. 1055 *NEW* Regulation JF-R — Student Admissions

This revision reflects the requirements of Chapter 102, HB 2621, which establishes procedures for serving students who reside in unorganized territories and students placed by a court or state placing agency. The legislation clarifies school district responsibilities related to Child Find activities, special education evaluations and services, enrollment, Certificates of Educational Convenience, and related definitions.

Because the comprehensive update to Section J has not yet been published, ASBA has created substantively identical regulations to accompany the affected policies as an interim measure. This approach maintains compliance with the new statutory requirements while simplifying the transition to the updated Section J. When the revised Section J is published, these interim regulations will be incorporated into the updated and consolidated documents and may then be removed with minimal effort.

Policy Advisory No. 1056 *NEW* Regulation JFAA-R — Admission of Resident Students

This revision reflects the requirements of Chapter 102, HB 2621, which establishes procedures for serving students who reside in unorganized territories and students placed

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by a court or state placing agency. The legislation clarifies school district responsibilities related to Child Find activities, special education evaluations and services, enrollment, Certificates of Educational Convenience, and related definitions.

Because the comprehensive update to Section J has not yet been published, ASBA has created substantively identical regulations to accompany the affected policies as an interim measure. This approach maintains compliance with the new statutory requirements while simplifying the transition to the updated Section J. When the revised Section J is published, these interim regulations will be incorporated into the updated and consolidated documents and may then be removed with minimal effort.

Policy Advisory No. 1057 ***NEW*** **Regulation JFAB-R — Tuition / Admission of Nonresident Students**

This revision reflects the requirements of Chapter 102, HB 2621, which establishes procedures for serving students who reside in unorganized territories and students placed by a court or state placing agency. The legislation clarifies school district responsibilities related to Child Find activities, special education evaluations and services, enrollment, Certificates of Educational Convenience, and related definitions.

Because the comprehensive update to Section J has not yet been published, ASBA has created substantively identical regulations to accompany the affected policies as an interim measure. This approach maintains compliance with the new statutory requirements while simplifying the transition to the updated Section J. When the revised Section J is published, these interim regulations will be incorporated into the updated and consolidated documents and may then be removed with minimal effort.

Policy Advisory No. 1058 ***NEW*** **Regulation JFABC-R — Admission of Transfer Students**

This revision reflects the requirements of Chapter 102, HB 2621, which establishes procedures for serving students who reside in unorganized territories and students placed by a court or state placing agency. The legislation clarifies school district responsibilities related to Child Find activities, special education evaluations and services, enrollment, Certificates of Educational Convenience, and related definitions.

Because the comprehensive update to Section J has not yet been published, ASBA has created substantively identical regulations to accompany the affected policies as an interim measure. This approach maintains compliance with the new statutory requirements while simplifying the transition to the updated Section J. When the revised Section J is published, these interim regulations will be incorporated into the updated and consolidated documents and may then be removed with minimal effort.

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Policy Advisory No. 1059 *NEW* Regulation JFABD-RB — Admission of Homeless Students

This revision reflects the requirements of Chapter 102, HB 2621, which establishes procedures for serving students who reside in unorganized territories and students placed by a court or state placing agency. The legislation clarifies school district responsibilities related to Child Find activities, special education evaluations and services, enrollment, Certificates of Educational Convenience, and related definitions.

Because the comprehensive update to Section J has not yet been published, ASBA has created substantively identical regulations to accompany the affected policies as an interim measure. This approach maintains compliance with the new statutory requirements while simplifying the transition to the updated Section J. When the revised Section J is published, these interim regulations will be incorporated into the updated and consolidated documents and may then be removed with minimal effort.

Policy Advisory No. 1060 *NEW* Regulation JFABDA-RB — Admission of Students in Foster Care

This revision reflects the requirements of Chapter 102, HB 2621, which establishes procedures for serving students who reside in unorganized territories and students placed by a court or state placing agency. The legislation clarifies school district responsibilities related to Child Find activities, special education evaluations and services, enrollment, Certificates of Educational Convenience, and related definitions.

Because the comprehensive update to Section J has not yet been published, ASBA has created substantively identical regulations to accompany the affected policies as an interim measure. This approach maintains compliance with the new statutory requirements while simplifying the transition to the updated Section J. When the revised Section J is published, these interim regulations will be incorporated into the updated and consolidated documents and may then be removed with minimal effort.

Policy Advisory No. 1061 *NEW* Regulation JFB-RB — Open Enrollment

This revision reflects the requirements of Chapter 102, HB 2621, which establishes procedures for serving students who reside in unorganized territories and students placed by a court or state placing agency. The legislation clarifies school district responsibilities related to Child Find activities, special education evaluations and services, enrollment, Certificates of Educational Convenience, and related definitions.

Because the comprehensive update to Section J has not yet been published, ASBA has created substantively identical regulations to accompany the affected policies as an interim measure. This approach maintains compliance with the new statutory requirements while

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simplifying the transition to the updated Section J. When the revised Section J is published, these interim regulations will be incorporated into the updated and consolidated documents and may then be removed with minimal effort.

Policy Advisory No. 1062 Policy JJAB — Limited Open / Closed Forum

This revision reflects the requirements of Chapter 4, HB 2312, establishing A.R.S. 15-120.08. The policy now provides that a public school may not deny a patriotic youth group equal access or a fair opportunity to meet in a designated open forum or limited public forum, or otherwise discriminate against the group based on its membership or leadership requirements or its oath of allegiance to God and country. The policy also incorporates the statutory procedures governing requests by patriotic youth groups to address students during the first quarter of the school year and the distribution of materials provided by those groups.

Policy Advisory No. 1063 Regulation JR-R — Student Records

The revision adds the new statutory requirements established by Chapter 28, SB 1126, amending A.R.S. 15-141. The Regulation now provides that, upon request and in accordance with the Family Educational Rights and Privacy Act (FERPA), a school must identify for a Department of Child Safety caseworker any school that has requested a student's educational records and any person who has withdrawn the student from school. It also requires the school to provide other requested information or records relating to a student who is or was enrolled at the school. In addition, the Regulation reflects the prohibition against preventing a school employee, contractor, or volunteer from speaking with a Department of Child Safety caseworker who is investigating an allegation of abuse or neglect.

Policy Advisory No. 1064 Policy KFA — Public Conduct on School Property

This policy has been comprehensively updated as part of ASBA's continuing review of the model policy manual. The revisions improve the organization and alignment of the policy with Arizona law governing public conduct on school property.

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If you have any questions, call Policy Services at (602) 254-1100. Ask for Dr. Charlotte Patterson, Policy Analyst; Lynne Bondi, Policy Analyst; or Renae Watson, Policy Technician. Our e-mail addresses are, respectively, [cpatterson@azsba.org], [lbondi@azsba.org] and [rwatson@azsba.org]. You may also fax information to (602) 254-1177.

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ADVISORY 1047

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BEDB ©
AGENDA

The agenda shall list the specific matters to be discussed, considered or decided at the meeting. Except for a meeting through technological devices, the agenda shall also include the time that the public will have physical access to the meeting place. The Governing Board may discuss, consider or make decisions only on matters listed on the agenda and other matters related thereto. (Subject to A.R.S. 38-431.02)

Preparation and Dissemination

Regular Meetings

The Superintendent will prepare Board meeting agendas in consultation with the Board President.

The Superintendent may place items on the agenda. Any Board member may propose an item for consideration of placement on the agenda and will notify the Superintendent of the particular item of business at least five (5) working days before the meeting.

The agenda and supporting materials shall be distributed to the Board members not less than twenty-four (24) hours prior to the meeting.

Copies of the agenda shall be available to the public and the press.

Special Meetings

Whenever possible, the procedures for agenda preparation and dissemination used for regular meetings will be used for special meetings.

These procedures may be altered by the Superintendent during an emergency or when compliance would be impractical. However, the Superintendent shall comply with all legal requirements in scheduling special meetings.

Order of Business

Unless changed by a majority vote of Board members present at a meeting, the order of business shall be as follows:

Regular meetings:

A. Call to order

B. Adoption of the agenda (*Discussion of items is not in order*.)

C. Pledge of allegiance

D. Board Meeting minutes not previously approved

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E. Information only items (*Items to be heard only; the Board will not propose, discuss, or take legal action during the meeting unless the specific matter is properly noticed for legal action*.)

1. Summary of current events

a. Superintendent

Celebrations and recognitions

b. Governing Board members

2. Reports (*Notice must be specific as to type of report that will be given, subject matter and whom will be making the report*.)

F. Public comments (*Members of the Governing Board shall not discuss or take legal action on matters raised during an open call to the public unless the matters are properly noticed for discussion and legal action*.)

G. Action items (*Matters on which the Governing Board may take legal action during the meeting*.)

1. Consent agenda items (*When so presented, should fully describe the matters on the agenda and inform the public where more information can be obtained*.)

A proposal to impose or increase a tax rate, assessment or fee in this state may not be placed on the consent agenda.

2. Specific items of District business (*As listed for consideration, may include various categorical areas as the business of the District necessitates Board discussion, deliberation, and action*.)

H. Information and Discussion items (*Matters about which the Board may engage in discussion but will take no action during the meeting*.)

I. Information items (*The Board will not propose, discuss, or take legal action during the meeting*.)

Requests for future agenda items

J. Adjournment

Special meetings:

A. Call to order

B. Items for which the special meeting was called (*May include timely action, discussion, and information items as conditioned for regular meetings*.)

C. Announcements

D. Adjournment

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Executive sessions:

An executive session may be scheduled, as necessary, during either a regular or special meeting. (*See Arizona Attorney General Agency Handbook Section 7.6.7.*)

1. When an executive session is to be held, the notice must state the specific provision of law authorizing the executive session. An agenda is also required and must contain a general description of the matters to be considered.

2. The following statement may be included on every agenda:

"The Board may vote to hold an executive session for the purpose of obtaining legal advice from the Board's attorney on any matter listed on the agenda pursuant to A.R.S. 38-431.03(A)(3)."

3. A matter that is discussed in executive session on which the Governing Board must take a final vote or make a final decision must be placed on the regular agenda and may not be placed on the consent agenda.

Emergency meetings

In the case of an actual emergency, the Governing Board, after giving such notice as is appropriate to the circumstances, may act on an emergency matter or call an emergency meeting in accordance with the requirements set out in A.R.S. 38-431.02. The emergency meeting shall follow the order of business for a special meeting. An emergency meeting shall be subsequently followed by the posting of a public notice within twenty-four (24) hours declaring that an emergency session has been held and setting forth the information specified by A.R.S. 38-431.02. Chapter 7 of the Arizona Agency Handbook shall be consulted for guidance when an emergency action or meeting is being considered.

Accommodations for Individual with Disabilities

Persons with a disability may request a reasonable accommodation, such as a sign language interpreter, by contacting [name of designated District contact person] at [provide telephone number and e-mail]. Requests should be made as early as possible to allow time to arrange the accommodation.

Adopted: _____

LEGAL REF.:
A.R.S.
38-431
38-431.01
38-431.02
38-431.03
28 CFR § 35.163
7.6.7 AZ Agency Handbook

CROSS REF.:
BDA - Board Organizational Meeting and Board President Duties
BE - School Board Meetings

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ADVISORY 1048

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QUALIFICATIONS AND DUTIES OF THE SUPERINTENDENT

Qualifications

The Superintendent shall have appropriate qualifications as determined by the Governing Board by action taken at a public meeting.

The Superintendent shall have a valid fingerprint card issued pursuant to A.R.S. 41-1758.03.

Duties

The Superintendent is the District's chief executive officer and the administrative head of all divisions and departments of the school system. It is the Superintendent's duty to administer the policies of the Board and to provide leadership for the entire school system. The Superintendent is the professional consultant to the Board and, in this capacity, makes recommendations to the Board for changes in Board policies and the educational program.

The Superintendent, as chief administrative officer of the District, shall supervise, either directly or through delegation, all activities and all personnel of the school system according to the laws of the state of Arizona, rules of the Arizona State Board of Education, and adopted policies of the Governing Board.

The Superintendent provides the initiative and the technical guidance for the improvement of the total program of the school system. The delegation of authority for the operation of the various functions of the school system is one of the Superintendent's duties. The Superintendent is, however, responsible to the Board for all functions of the District, including but not limited to those listed below.

Education:

A. Administers the development, coordination, maintenance, and evaluation of all educational programs.

B. Supervises methods of teaching, supervision, and administration in effect in the schools.

C. Keeps informed of modern educational thought and practices by advanced study, by visiting school systems elsewhere, by attending educational conferences, and by other appropriate means.

D. Keeps the public informed about modern education practices, educational trends, and the policies, practices, and problems in the District schools.

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Management:

A. Ensures that all activities of the District are conducted in accordance with the laws of the state of Arizona, the regulations of the Arizona Board of Education, and the policies of the Governing Board.

B. Assumes responsibility for the overall financial planning of the District and for the preparation of the annual budget and submission of it to the Board for review and approval.

C. Establishes and maintains efficient procedures and effective controls for all expenditures of school funds in accordance with the adopted budget, subject to direction and approval of the Board.

D. Maintains adequate records for the schools, including, but not limited to:

1. financial accounts,

2. business and property records,

3. personnel,

4. school population,

5. student records including verifiable documentation of each student's residency in this state in accordance with guidelines and forms adopted by the Arizona Department of Education, and

6. scholastic records.

E. Provides suitable instructions and regulations to govern the maintenance of District properties.

F. Provides suitable instructions and regulations to govern the safety and transportation of students.

G. Assumes responsibility for the use of buildings and grounds.

H. Recommends the locations and sizes of new school sites and of additions to existing sites; the locations and sizes of new buildings; the plans for new school buildings; all appropriations for sites and buildings; and improvements, alterations, and changes in the buildings and equipment of the District.

I. Oversees the processing and submission of required reports.

J. Interprets the budget and finances to the community.

K. Remains current on new legislation and implements laws to the best advantage of the District.

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Governing Board:

A. Attends and participates in all meetings of the Board and its committees, except when excused by the Board.

B. Takes prompt action to implement all directives of the Board.

C. Advises the Board on the need for new and/or revised policies.

D. Provides timely advice to the Board on the implication of changes in statutes or regulations affecting education.

E. Informs and advises the Board about programs, practices, and problems of the schools, and keeps the Board informed of the activities operating under the Board's authority.

> If the District has a weapons detection system at a school operated by the District, the Governing Board may authorize the Superintendent to modify the system without prior approval by the Governing Board. If authorized to modify the system, the Superintendent shall report each modification to the Governing Board not later than twenty-four (24) hours after the modification is made. No person other than the Superintendent may be authorized to modify the weapons detection system without prior approval by the Governing Board.

F. Prepares and submits to the Board recommendations relative to all matters requiring Board action, placing before the Board such facts, objective information, and reports as are needed to ensure the making of informed decisions.

G. Develops and implements rules and regulations in keeping with Board policy.

H. Acts as chief public relations agent for the District.

I. Acts on own discretion if action is necessary in any matter not covered by Board policy, reports such action to the Board as soon as practicable, and recommends policy guidance in the future.

Personnel:

A. Recommends to the Board the appointment or dismissal of all employees of the District.

B. Ensures that all employees are evaluated in accordance with the schedule established by the Board.

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C. Determines assignments, defines the duties, and coordinates and directs the work of all employees of the District.

D. Recommends all promotions, demotions, and salary changes to the Board.

E. Communicates to all employees all actions of the Board relating to personnel matters, and receives from employees all communications to be made to the Board.

Adopted: _____

LEGAL REF.:
A.R.S.
15-341
15-503
15-802
38-201
41-1758
A.A.C.
R7-2-603

CROSS REF.:
CBI - Evaluation of Superintendent

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ADVISORY 1049

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DJ ©
PURCHASING ETHICS

Governing Board

The District's Governing Board members and employees shall not use their offices or positions to receive any valuable things or benefits that would not ordinarily accrue to them in the performance of duties if the things or benefits are of such value or character as to manifest a substantial and improper influence upon the performance of their duties.

Food and Beverages

The Governing Board may provide food and beverages at School District events, including official school functions and trainings, as allowed by the Arizona Constitution, laws pertaining to travel and subsistence, gifts, grants (including federal grants), or devises, and policies of the Department of Education.

Food and beverage purchases shall be approved in advance by the Governing Board. For each purchase, the Governing Board will approve the total amount to be spent or an allowable per-person cost and identify the District fund to be used. The District will document how the purchase benefits the District and serves a public purpose and will determine that the purchase complies with applicable state law, the Arizona Constitution's Gift Clause, and the allowable uses of the identified funding source.

Personal Gift or Benefit

A person who supervises or participates in contracts, purchases, payments, claims or other financial transactions, or a person who supervises or participates in the planning, recommending, selecting or contracting for materials, services, goods, construction, or construction services of a school district or school purchasing cooperative is guilty of a Class 6 felony if the person solicits, accepts or agrees to accept any personal gift or benefit with a value of three hundred dollars ($300) or more from a person or vendor that has secured or has taken steps to secure a contract, purchase, payment, claim or financial transaction with the school district or school purchasing cooperative. Soliciting, accepting or agreeing to accept any personal gift or benefit with a value of less than three hundred dollars ($300) is a Class 1 misdemeanor.

Any person or vendor who has secured or has taken steps to secure a contract, purchase, payment, claim or financial transaction with a school district or school purchasing cooperative that offers, confers or agrees to confer any personal gift or benefit with a value of three hundred dollars ($300) or more on a person who supervises or participates in contracts, purchases, payments, claims or other financial transactions, or on a person who supervises or participates in planning,

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recommending, selecting or contracting for materials, services, goods, construction or construction services of a school district or school purchasing cooperative, is guilty of a Class 6 felony. Offering, conferring or agreeing to confer any personal gift or benefit with a value of less than three hundred dollars ($300) is a Class 1 misdemeanor.

Definitions

For the purpose of this policy, a *gift* or *benefit* means a payment, distribution, expenditure, advance, deposit or donation of monies, any intangible personal property or any kind of tangible personal or real property. A *gift* or *benefit* does not include an item of nominal value such as a greeting card, t-shirt, mug or pen. A *gift* or *benefit* does not include food or beverage, or expenses or sponsorships relating to a special event or function to which individuals involved in procurement and purchasing are invited.

Reprisals

A District employee who has control over personnel actions may not take reprisal against a District employee or that employee's disclosure of information that is a matter of public concern, including a violation of District policy or laws/regulations governing the District.

Adopted: _____

LEGAL REF.:
A.R.S.
15-213
15-323
15-341
15-342
38-501 to 38-511
A.A.C.
R7-2-1001 to R7-2-1003
R7-2-1308
Uniform System of Financial Records (USFR)
Article IX, section 7, Constitution of Arizona
Policies adopted by the Department of Education

CROSS REF.:
DJE - Bidding/Purchasing Procedures
GBEAA - Conflict of Interest

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ADVISORY 1050

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BIDDING / PURCHASING PROCEDURES

The Superintendent shall be responsible for all purchasing, contracting, competitive bidding, and receiving and processing of all bid protests, in accordance with the Arizona school district procurement rules, including A.A.C. R7-2-1141 *et seq*. A contract shall not be awarded to an entity that does not verify employment eligibility of each employee through the E-verify program in compliance with A.R.S. 23-214 subsection A. Each contract shall contain the warranties required by A.R.S. 41-4401 relative to the E-verify requirements. District purchases shall also be in accordance with 2 C.F.R. 200 (Code of Federal Regulations Title 2).

The Superintendent shall ensure that all aspects of bidding and purchasing procedures conform to federal and state laws, rules and regulations, including A.R.S. 38-503(C). The Superintendent shall establish administrative regulations to ensure the District is in full compliance, including contracting with small and minority businesses, women's business enterprises, veteran-owned businesses, and labor surplus area firms. (2 C.F.R. 200.321).

Bidding

The District is not required to engage in competitive bidding in order to place a student in a private school that provides special education services if such placement is prescribed in the student's individualized education program and the private school has been approved by the Department of Education Division of Special Education pursuant to A.R.S. 15-765. The placement is not subject to rules adopted by the State Board of Education before November 24, 2009 pursuant to A.R.S. 15-213.

The District may, without competitive bidding, purchase or contract for any products, materials and services directly from Arizona Industries for the Blind, certified nonprofit agencies that serve individuals with disabilities and Arizona Correctional Industries if the delivery and quality of the goods, materials or services meet the District's reasonable requirements.

Intergovernmental agreements and contracts between school districts or between the District and other governing bodies as provided in A.R.S. 11-952 are exempt from competitive bidding under the procurement rules adopted by the State Board of Education pursuant to A.R.S. 15-213.

The District is not required to engage in competitive bidding to make a decision to participate in insurance programs authorized by A.R.S. 15-382.

The District is not required to obtain bid security for the construction-manager-at-risk method of project delivery.

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Online Bidding

Until such time as the State Board of Education adopts rules for the procurement of goods and information services by school districts and charter schools using electronic, online bidding, the District may procure goods and information services pursuant to A.R.S. 41-2671 through 2673 using the rules adopted by the Department of Administration in implementing 41-2671 through 2673.

Except as otherwise provided below, only purchases of ~~ten~~ fifteen thousand dollars (~~$10~~ 15,000) or more are subject to competitive bidding requirements.

Purchasing

Purchases from District Employees

Districts are required to follow the School District Procurement Rules for all purchases of goods or services from District employees regardless of dollar amount. A.R.S. 38-503(C) prohibits public employees from providing their employers with any equipment, material, supplies, or services unless provided under an award or contract let after public competitive bidding. Districts must follow the School District Procurement Rules, regardless of the expenditure amount, when purchasing goods or services from District employees. This applies to any purchase using District monies, including extracurricular activities fees tax credit contributions and monies held in trust by the District, such as student activities monies. Although the School District Procurement Rules exempt expenditures of student activities monies from the Rules, that exemption does not apply to purchases in which a District employee acts as a vendor.

Purchases from District Board Members

Districts are required to follow the School District Procurement Rules for all purchases of services from District Board members regardless of dollar amount. A.R.S. 38-503(C) prohibits governing board members from providing their district with any services, unless provided under an award or contract let after public competitive bidding. However, for purchases of supplies, materials, and equipment from district board members, districts are required to follow the School District Procurement Rules only if the purchase exceeds one hundred thousand dollars ($100,000). Purchases below the one hundred thousand dollar ($100,000) threshold must comply with the guidelines for written quotes. For districts with three thousand (3,000) or more students, statutes limit purchases of supplies, materials, and equipment from board members to three hundred dollars ($300) per transaction and one thousand dollars ($1,000) total within any twelve (12)-month period and require that the governing board adopt a policy authorizing such purchases within the preceding twelve (12) months. Districts with fewer than three thousand (3,000) students may purchase supplies, materials, and equipment from governing board members in any amount, provided each purchase is approved by the governing board and the amount of the purchase is included in the board's meeting minutes.

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Purchases Requiring Bidding

For transactions of at least ~~ten~~ fifteen thousand dollars (~~$10~~ 15,000) and less than one hundred thousand dollars ($100,000), written price quotations will be requested from at least three (3) vendors. If three (3) written price quotations cannot be obtained, documentation showing the vendors contacted that did not offer written price quotations, or explaining why written price quotations were not obtained, shall be maintained on file in the District office.

For transactions to purchase construction, materials, or services costing more than one hundred thousand dollars ($100,000), sealed bids and proposals shall be requested.

All transactions must comply with the applicable requirements of the Arizona Revised Statutes, the Arizona Administrative Code and the Uniform System of Financial Records.

Purchases Not Requiring Bidding

Except as otherwise provided above, purchases of less than ~~ten~~ fifteen thousand dollars (~~$10~~ 15,000) may be made at the discretion of the Superintendent. Such procurements are not subject to competitive purchasing requirements; however, reasonable judgment should be used to ensure the purchases are advantageous to the District.

Contract Requirements

Contract Duration

Unless otherwise provided by law, contracts for materials or services and contracts for job-order-contracting construction services may be entered into if the duration of the contract and the conditions of renewal or extension, if any, are included in the invitation for bids or the request for proposals and if monies are available for the first fiscal period at the time the contract is executed. The duration of contracts for materials or services and contracts for job-order-contracting construction services shall be limited to no more than five (5) years unless the Board determines that a contract of longer duration would be advantageous to the District. Once determined, the decision should be memorialized in meeting minutes and in the contract/bid file. Payment and performance obligations for succeeding fiscal periods are subject to the availability and appropriation of monies. The maximum dollar amount of an individual job order for a job-order-contracting construction service shall be one million dollars ($1,000,000) or as determined by the Board.

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Public Inspection and Rationale for Awarding a Contract

The Governing Board shall make available, for public inspection, all information, all bids, proposals and qualifications submitted, and all findings and other information considered in determining whose bid conforms to the District's invitation for bids. The documentation provided will include information regarding the most advantageous, with respect to price, conformity to the specifications, and other factors, or whose proposal for qualifications are to be used to select and award the bid. Included in this information will be the rationale for awarding a contract for any specified professional services, construction, construction service or materials to an entity selected from a qualified select bidders list or through a school purchasing cooperative. The invitation for bids, request for proposals or request for qualifications shall include a notice that all information and bids, proposals and qualifications submitted will be made available for public inspection.

Requirement: Registered Sex Offender Prohibition

All purchase orders, agreements to purchase, and contracts for services to be provided by personnel other than District employees must include the following statement on the document:

> ***Registered Sex Offender Restriction.*** *Pursuant to this order, the named vendor agrees by acceptance of this order that no employee or subcontractor of the vendor, who is required to register as a sex offender, pursuant to A.R.S. 13-3821, will perform work on District premises or equipment at any time when District students are, or are reasonably expected to be, present. The vendor further agrees by acceptance of this order that a violation of this condition shall be considered a material breach and may result in a cancellation of the order at the District's discretion.*

Adopted: _____

LEGAL REF.:
A.R.S.
11-952
15-213
15-213.01
15-213.02
15-239
15-323
15-342
15-382
15-765
15-910.02

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23-214
34-101 *et seq*.
35-391 *et seq*.
35-393 *et seq*.
38-503
38-511
39-121
41-2632
41-2636
41-4401
A.A.C.
R7-2-1001 *et seq*.
R7-2-1023
R7-2-1029
A.G.O.
I83-136
I87-035
I06-002
Uniform System of Financial Records
2 C.F.R. 200
2 C.F.R. 200.321

CROSS REF.:
BCB - Board Member Conflict of Interest
DJ - Purchasing Ethics
DJG - Vendor/Contractor Relations and Sales Calls Requirements
GBEAA - Conflict of Interest
JLIF - Sex Offender Notification

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BASIC INSTRUCTIONAL PROGRAM

The various instructional programs will be developed to maintain a balanced, integrated, and sequential curriculum that will serve the educational needs of all school-aged children in the District. The curriculum will be broad in scope and provide for a wide range in rate, readiness, and potential for learning.

The instructional program shall reflect the importance of language acquisition/reading-skill development as the basic element in each student's education. The first priority of the instructional program will be language acquisition through a planned sequence of reading skills and language experiences beginning in the kindergarten program. The improvement of specific reading skills of students should be continuous throughout their education. Each school educating students in kindergarten and grades one (1) through three (3) shall have a reading program as required by A.R.S. 15-704 and applicable State Board of Education rules.

The second priority of the instructional program will be mastery of the fundamentals of mathematics, beginning in the kindergarten program.

If an advanced mathematics course is available, the District shall enroll a student entering grades six (6), seven (7), or eight (8) in the next advanced mathematics course for which the student qualifies, unless the student's parent objects. Automatic enrollment applies if the student demonstrates the highest level of proficiency in grade-level mathematics in either the statewide assessment or a benchmark assessment per A.R.S. 15-708.

When a student is automatically enrolled, the District shall notify the student's parent of the purpose and goals of the automatic enrollment and provide instructions for objecting to the placement.

The instructional program will ensure that on or before July 1, 2022, at least one (1) kindergarten through third (K-3) grade teacher, literacy coach or literacy specialist in each school has received training related to dyslexia that complies with the requirements prescribed in A.R.S. 15-219 and A.R.S. 15-501.01 which includes enabling teachers to understand and recognize dyslexia and to implement structured literacy instruction that is systematic, explicit, multisensory and evidence-based to meet the educational needs of students with dyslexia.

Attention to the above-listed priorities shall not result in neglect of other areas of the curriculum.

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Minimum Course of Study for Students in the Common Schools

Students shall demonstrate competency as defined by the State Board-adopted academic standards, at the grade levels specified, in the following required subject areas:

A. English language arts (ELA);

B. Mathematics;

C. Social studies; including:

1. Civics; and

2. Instruction on the Holocaust and other genocides for at least three (3) class periods, or the equivalent, on at least two (2) separate occasions during any of grades seven through twelve (7-12).

3. Instruction in the Constitutions of the United States and Arizona, American institutions and ideals and in the history of Arizona, including the history of Native Americans in Arizona for a total of one (1) year during kindergarten (K) through eighth (8th) grades.

D. Science;

E. Two (2) or more of the following:

1. Visual Arts

2. Dance

3. Theatre

4. Music

5. Media Arts

F. Health/Physical education, including mental health. Mental health instruction may be included as part of other subject areas and shall comply with A.R.S. § 15-701.03.

Minimum Course of Study for Graduation from High School

See Policy IKF.

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Observance Days

September 11, in each year shall be observed as 9/11 Education Day. On 9/11 Education Day, each public school that provides instruction to students in any of grades seven (7) through twelve (12) shall provide age-appropriate instruction to students in each of grades seven (7) through twelve (12) on the terrorist attacks of September 11, 2001.

September 25, in each year, shall be observed as Sandra Day O'Connor Civics Celebration Day. On Sandra Day O'Connor Civics Celebration Day, each public school in this state shall dedicate the majority of the school day to civics education.

If Sandra Day O'Connor Civics Celebration Day or 9/11 Education Day falls on a Saturday, Sunday or other day when a public school is not in session, the preceding or following school day shall be observed in the public school as the holiday.

The Superintendent is directed to emphasize the use of the resources developed by the State Board of Education relating to civics education which align with the academic standards in social studies pursuant to A.R.S. 15-701 and 15-701.01.

Adopted: _____

LEGAL REF.:
A.R.S.
1-319
1-321
15-203
15-211
15-219
15-341
15-501.01
15-701
15-701.01
15-701.03
15-704
15-708
15-710
15-710.02
15-741.01
15-802
A.A.C.
R7-2-301 et seq.

CROSS REF.:
IJNDB - Use of Technology Resources in Instruction
IKF - Graduation Requirements

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REGULATION

SPECIAL INSTRUCTIONAL PROGRAMS

(Identification and Placement of Exceptional Students)

This detailed administrative regulation is issued to:

A. Accomplish the requirements of the Governing Board set out in Policy IHB - Special Instructional Programs.

B. Assure District compliance with the requirements of applicable federal and state laws and the lawful regulations of the State Board of Education.

C. Aid District personnel in fulfilling their duties relating to the topic by presenting the procedural information in a format that aligns with the Arizona Department of Education/Exceptional Student Services (ADE/ESS) compliance checklists.

Citations from the following sources are annotated to the material to assist in conducting research and for clarification:

A. Arizona Revised Statutes (A.R.S.)

B. Arizona Administrative Code (A.A.C.) Title 7, Chapter 2, State Board of Education Rules

C. Regulations of the Family Educational Rights and Privacy Act as published in Part 99 of Title 34 of the Code of Federal Regulations (C.F.R.)

D. Regulations to the Individuals with Disabilities Education Act (IDEA) as published in Title 34 of the C.F.R., Part 300.

Whenever the term "District" is used in this regulation, it is to be interpreted contextually to mean the School District, the respective local school site, a representative of the District or a representative of the local school site, as is applicable to the circumstance.

Applicability

To accommodate the necessity to present procedural information in a format that aligns with the Arizona Department of Education/Exceptional Student Services (ADE/ESS) compliance checklists, this generic regulation contains procedural requirements for covered individuals of all ages. However, any statement in this regulation that addresses a provision that is not applicable to the grade levels and age ranges included in the student membership of the District is to be considered for the purposes of compliance to be not applicable.

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Child Find

Procedures for child identification and referral shall meet the requirements of the IDEA and its regulations, A.R.S. Title 15, chapter 7, and its regulations, and the State Board of Education rules R7-2-401.

The District is responsible for child identification activities for children whose parents reside in the District unless:

A. The student is enrolled in a charter school or public education agency that is not a school district. In that event, the charter school or public education agency is responsible for child identification activities;

B. The student is enrolled in a nonprofit private school. In that event, the District within whose boundaries the private school is located is responsible for child identification activities.

The District will identify, locate, and evaluate all children with disabilities within its geographic boundaries who are in need of special education and related services including, but not limited to, children who are:

A. Homeless;

B. Highly mobile, including migrant children;

C. Wards of the state; and,

D. Attending private schools or who are homeschooled.

In its identification process the District will include children who are suspected of being children with a disability and in need of special education, even though:

A. They are advancing from grade to grade; or

B. They are highly mobile children, including those who are migrant children. [34 C.F.R. 300.111]

The District will maintain a record of children who are receiving special education and related services. [34 C.F.R. 300.111]

The District will inform the general public and all parents within its boundaries of the responsibility of the availability of special education services for students aged three (3) through twenty-one (21) years, and how those services may be accessed including information regarding early intervention services for children aged birth through two (2) years. Services for an eligible student with a disability shall extend through conclusion of the instructional year during which the student attains the age of twenty-two (22). [A.A.C. R7-2-401.C]

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The District shall establish, implement, and make available (either in writing or electronically) to its school-based personnel, and all parents within District boundaries of responsibility for the identification and referral of all children with disabilities aged birth (0+) through 21 (twenty-one), including children with disabilities attending private schools and home schools, regardless of the severity of their disability. [A.A.C. R7-2-401.D]

The District shall require appropriate school-based personnel to review the written procedures related to child identification and referral on an annual basis. The District shall maintain documentation of school-based personnel review. [A.A.C. R7-2-401] Identification screening for possible disabilities shall be completed within forty-five (45) calendar days after:

A. Entry of each preschool or kindergarten student and any student enrolling without appropriate records or screening, evaluation, and progress in school; or

B. Notification to the District by parents of concerns regarding developmental or educational progress by their child (aged three [3] years through twenty-one [21] years). [A.A.C. R7-2-401].

Screening procedures shall include vision and hearing status and consideration of the following areas:

A. Cognitive or academic;

B. Communication;

C. Motor;

D. Social or behavioral; and

E. Adaptive development. [A.A.C. R7-2-401]

Screening does not include detailed individualized comprehensive evaluation procedures. [A.A.C. R7-2-401]

For a student transferring into a school, the District shall review enrollment data and educational performance in the prior school. If there is a history of special education for a student not currently eligible for special education, or poor progress, the name of the student shall be submitted to the administrator for consideration of the need for a referral for a full and individual evaluation or other services. [A.A.C. R7-2-401.D]

If a concern about a student is identified through screening procedures or review of records, the parents of the student shall be notified of the concern within ten (10) school days and informed of the District's procedures to follow-up on the student's needs. [A.A.C. R7-2-401.D]

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The District shall maintain documentation of the identification procedures utilized, the dates of entry into school, notification by parents of a concern and the dates of screening. The results shall be maintained in the student's permanent records in a location designated by the administrator, should the student be enrolled or not enrolled in the District. [A.A.C. R7-2-401.D]

If the identification process indicates a possible disability, the name of the student shall be submitted to the administrator for consideration of the need for a referral for a full and individual evaluation or other services. A parent or a student who has reached the age of majority may request an evaluation of the student. [A.A.C. R7-2-401.D]

If, after consultation with the parent, the District determines that a full and individual evaluation is not warranted, the District shall provide prior written notice and procedural safeguards notice to the parent in a timely manner. [A.A.C. R7-2-401.D]

Confidentiality

The District will permit parents to inspect and review any education records relating to their children that are collected, maintained or used by the District under Individuals with Disabilities Education Act (IDEA). The District will comply with a request without unnecessary delay and in no case more than forty-five (45) calendar days after the request has been made, and before:

A. Any individualized education program (IEP) meeting;

B. Any hearing involving a due process complaint or disciplinary hearing;

C. Any resolution session. [34 C.F.R. 300.613]

The right to inspect and review education records includes:

A. The right to a response from the District to reasonable requests for explanations and interpretations of the records;

B. The right to request that the District provide copies of the records if failure to provide those copies would effectively prevent the parent from exercising the right to inspect and review the records; and

C. The right to have a representative of the parent inspect and review the records. [34 C.F.R. 300.613]

The District may presume that the parent has authority to inspect and review records relating to his or her child unless the District has been advised to the contrary by legal proceeding involving guardianship, separation and divorce. [34 C.F.R. 300.613]

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The District will keep a record of parties obtaining access to education records collected, maintained or used under IDEA (except access by parents and authorized employees of the District), including:

A. The name of the party;

B. The date access was given; and

C. The purpose for which the party is authorized to use the records. [34 C.F.R 300.614]

If any education record includes information on more than one (1) child, the parents of those children have the right to inspect and review only the information relating to their child. [34 C.F.R 300.615]

The District will provide parents on request a list of the types and locations of education records collected, maintained or used by the District. [34 C.F.R 300.616]

The District may charge a fee for copies of records that are made for parents if the fee does not effectively prevent the parents from exercising their right to inspect and review records. [34 C.F.R 300.617]

The District will not charge a fee to search for or to retrieve information. [34 C.F.R 300.615]

A parent who believes that information in the education records collected, maintained or used by the District is inaccurate or misleading or violates the privacy or other rights of the child, may request the District to amend the information. [34 C.F.R 300.618]

The District will decide whether to amend the information in accordance with the request in a reasonable period of time of receipt of the request. [34 C.F.R 300.618]

If the District refuses to amend the information in accordance with the request, it will inform the parent of the refusal and advise the parent of the right to a hearing under 34 C.F.R 300.619. [34 C.F.R 300.618]

The District will, on request, provide an opportunity for a hearing to challenge information in education records to ensure that it is not inaccurate, misleading, or otherwise in violation of the privacy or other rights of the child. [34 C.F.R 300.619]

If, as a result of a hearing, the District decides to amend information determined inaccurate, misleading, or otherwise in violation of the privacy or other rights of the child, it will do so accordingly and so inform the parent in writing. [34 C.F.R 300.620]

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If, as a result of a hearing, the District decides that the information is not inaccurate, misleading, or otherwise in violation of the privacy or other rights of the child, the District will inform the parent of the parent's right to place in the maintained records a statement commenting on the information or setting forth any reasons for disagreeing with the District's decision. [34 C.F.R 300.620]

Parental consent will be obtained before personally identifiable information is disclosed to parties other than participating agencies, unless the information is contained in education records and the disclosure is authorized without parent consent under Family Educational Rights and Privacy Act (FERPA). [34 C.F.R 300.622]

Parental consent will be obtained before personally identifiable information is released to officials of participating agencies providing or paying for transition services in accordance with §300.321. [34 C.F.R 300.622]

If a child is enrolled, or is going to enroll in a private school that is not located in the boundaries of the district of the parent's residence, parental consent will be obtained before any personally identifiable information about the child is released between officials in the district where the private school is located and officials in the district of the parent's residence. [34 C.F.R 300.622]

Upon receiving a written request, the District shall forward special education records to any other public education agency in which a student has enrolled or is seeking to enroll. Records shall be forwarded within the time-frame specified in A.R.S. 15-828(F). The District shall also forward records to any other person or agency for which the parents have signed consent. [A.A.C. R7-2-401.J(4)]

The District will protect the confidentiality of personally identifiable information at collection, storage, disclosure, and destruction stages. [34 C.F.R 300.623]

One (1) official at the District will assume responsibility for ensuring the confidentiality of any personally identifiable information.

All persons collecting or using personally identifiable information will receive training or instruction regarding the State's policies and procedures under 300.123 and FERPA (34 C.F.R. part 99). [34 C.F.R 300.623]

The District will maintain, for public inspection, a current listing of the names and positions of its employees who may have access to personally identifiable information. [34 C.F.R 300.623]

The District shall establish, implement, and make available to its personnel and parents written policies and procedures to ensure the confidentiality of records and information in accordance with IDEA and its regulations, the Family Educational Rights and Privacy Act (FERPA) and its regulations, and state statutes. [A.A.C. R7-2-401.J(1)]

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The District will inform parents when personally identifiable information collected, maintained, or used for IDEA purposes is no longer needed to provide educational services to the child. [34 C.F.R 300.624]

The information will be destroyed at the request of the parents. However, a permanent record of a student's name, address, and phone number, his or her grades, attendance record, classes attended, grade level completed, and year completed may be maintained without time limitation. [34 C.F.R 300.624]

Parents shall be fully informed about the requirements of the IDEA and regulations, including an annual notice of the policies and procedures that the District shall follow regarding storage, disclosure to a third party, retention, and destruction of personally identifiable information. [A.A.C. R7-2-401.J(2)

The rights of the parents regarding educational records are transferred to the student at age eighteen (18) under FERPA unless the student has been declared legally incompetent, or the student has executed a delegation of rights to make educational decisions pursuant to A.R.S. 15-773. [34 C.F.R 300.625]

If the rights of the parents regarding educational records are transferred to the student at age eighteen (18) under the IDEA, the District will provide any notice required under the procedural safeguards provisions. [34 C.F.R 300.625]

The rights of parents regarding education records are transferred to the student at age 18, unless the student has been adjudicated incapacitated, or the student has executed a delegation of rights to make educational decisions pursuant to A.R.S. 15-773. [A.A.C. R7-2-401.J(3)]

Discipline

On a case-by-case basis and in consideration of any unique circumstances, school personnel may remove a child with a disability who violates a student code of conduct from his or her current placement to an appropriate interim alternative educational setting, another setting, or suspension, for not more than ten (10) consecutive school days (to the extent those alternatives are applied to children without disabilities), and for additional removals of not more than ten (10) consecutive school days in that same school year for separate incidents of misconduct, as long as those removals do not constitute a change of placement under §300.536. [34 C.F.R. 300.530]

After a child with a disability has been removed from his or her current placement for ten (10) school days in the same school year, during any subsequent days of removal the District will provide services to the extent required to:

A. Enable the child to continue to participate in the general education curriculum, although in another setting, and to progress toward meeting his/her IEP goals; and

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B. Receive, as appropriate, a functional behavioral assessment, behavioral intervention services and modifications that are designed to address the behavior violation so that it does not recur. [34 C.F.R. 300.530]

The District is only required to provide services during periods of removal to a child with a disability who has been removed from his or her current placement for the (10) days or less in that school year, if it provides services to non-disabled children similarly removed. [34 C.F.R. 300.530]

After a child with a disability has been removed from his or her current placement for ten (10) school days, and the current removal is for not more than ten (10) consecutive school days and not a change of placement, school personnel, in consultation with at least one of the child's teachers, determine the extent to which services are needed, so as to enable the child to continue to participate in the general education curriculum and to progress toward meeting the individualized education program (IEP) goals. [34 C.F.R. 300.530]

If the removal is a change in placement, the child's IEP team determines the appropriate services. [34 C.F.R. 300.530]

Within ten (10) school days of any decision to change the placement of a child with a disability because of a violation of a code of student conduct, the District, parent, and relevant members of the IEP team will review all relevant information in the student's file, the IEP, teacher observations, and any relevant information to determine:

A. If the conduct was caused by, or had a direct and substantial relationship to, the child's disability; or

B. If the conduct in question was the direct result of the District's failure to implement the IEP. [34 C.F.R. 300.530]

The conduct will be determined to be a manifestation of the disability if either of the above-named conditions occurred, and, if the IEP was not implemented, the District will take immediate steps to remedy that deficiency. [34 C.F.R. 300.530]

If the District, parent, and relevant members of the IEP team determine that the conduct was a manifestation of the child's disability, the child will be returned to the placement from which the child was removed, unless the parent and District agree to a change of placement. The IEP team will either:

A. Conduct a functional behavioral assessment, unless already done, and implement a behavioral intervention plan; or

B. If a behavioral intervention plan has already been developed, review the plan and modify it, as necessary, to address the behavior. [34 C.F.R. 300.530]

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School personnel may remove a student to an interim alternative educational setting for not more than forty-five (45) school days without regard to manifestation of disability if the child:

A. Carries a weapon to or possesses a weapon at school, on school premises, to or at a school function under the jurisdiction of the state or the District;

B. Knowingly possesses or uses illegal drugs, or sells or solicits the sale of a controlled substance, while at school, on school premises, or at a school function under the jurisdiction of the state or the District; or

C. Has inflicted serious bodily injury upon another person while at school, on school premises, or at a school function under the jurisdiction of the state or the District. [34 C.F.R. 300.530]

The District will notify parents and provide notice of procedural safeguards on the day the District determines the student has violated the code of conduct, and the violation constitutes a change in placement (i.e., interim alternative education setting). [34 C.F.R. 300.530]

The District shall establish, implement, and make available to personnel and parents written procedures for the suspension and expulsion of students with disabilities. [A.A.C. R7-2-401.P]

The District shall require all school-based staff involved in the disciplinary process to review the policies and procedures related to suspension and expulsion on an annual basis. [A.A.C. R7-2-401.P]

The District shall maintain documentation of staff review. [A.A.C. R7-2-401.P]

Procedures for such suspensions and expulsions shall meet the requirements of the IDEA and its regulations, and state statutes. [A.A.C. R7-2-401.P]

The child's IEP team determines the interim alternative educational setting for services. [34 C.F.R. 300.531]

The parent of a child with a disability who disagrees with any decision regarding placement under §§300.530 and 300.531 or the manifestation determination may appeal the decision by requesting an expedited due process hearing in conformance with §§300.532(C) and A.A.C. R7-2-405.I. [34 C.F.R. 300.532]

When the District believes that maintaining the current placement of the child is substantially likely to cause injury to the child or others the District may appeal the decision by requesting an expedited due process hearing in conformance with §§300.532(C) and A.A.C. R7-2-405.I. [34 C.F.R. 300.532]

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The student will remain in the interim alternative educational setting pending the decision of the hearing officer or expiration of the interim setting, whichever comes first, unless the parent and District agree otherwise. [34 C.F.R. 300.533]

A non-eligible student who engaged in a behavior that violated a code of student conduct may assert protections if the District had knowledge that the child was a child with a disability before the behavior that precipitated the disciplinary action occurred. The District will be deemed to have such knowledge if:

A. The parent of the child expressed concern in writing to supervisory or administrative personnel of the District, or a teacher of the child, that the child is in need of special education and related services;

B. The parent of the child requested an evaluation of the child pursuant to §§300.300 through 300.311; or

C. The teacher of the child, or other personnel of the District, expressed specific concerns about a pattern of behavior demonstrated by the child directly to the director of special education or to other supervisory personnel of the District. [34 C.F.R. 300.534]

The District will not be deemed to have knowledge if the parent of the child:

A. Has not allowed an IDEA evaluation of the child;

B. Has refused special education services for the child; or

C. The child has been evaluated and determined to not be a child with a disability under IDEA. [34 C.F.R. 300.534]

When the District does not have knowledge that a child is a child with a disability prior to taking disciplinary measures against the child, the child may be disciplined as other children without disabilities who engage in comparable behaviors.

If an evaluation is requested during the time in which a child is subjected to disciplinary measures, the evaluation will be conducted in an expedited manner.

A. Until the evaluation is completed, the child remains in the educational placement determined by the District, which can include suspension or expulsion without educational services.

B. If the child is determined to be a child with a disability, the District will provide special education and related services in accordance with this part, including the requirements of §§300.530 through 300.536. [34 C.F.R. 300.534]

The District may report a crime committed by a child with a disability to appropriate authorities to enable them to exercise their responsibilities. 34 C.F.R. 300.535]

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When reporting a crime committed by a child with a disability the District ensures that copies of the special education and disciplinary records of the child are transmitted for consideration by the appropriate authorities to whom the District reports the crime, but only to the extent permitted by FERPA. [34 C.F.R. 300.535]

A change of placement occurs if:

A. The removal is for more than ten (10) consecutive school days; or

B. The child has been subjected to a series of removals that constitute a pattern:

1. because the series of removals total more than ten (10) school days in a school year;

2. because the child's behavior is substantially similar to the behavior in previous incidents that resulted in a series of removals; and

3. because of such additional factors as the length of each removal, the total amount of time the child has been removed, and the proximity of the removals to one another. [34 C.F.R. 300.536]

The District will determine on a case-by-case basis whether a pattern of removals constitutes a change of placement, and such determinations are subject to review through due process and judicial proceedings. [34 C.F.R. 300.536]

Evaluation and Eligibility

The District, when proposing to conduct an initial evaluation to determine if a child qualifies as a child with a disability, and after reviewing existing data with the parents and providing prior written notice, will obtain informed consent from the parent of the child before collecting any additional data.

A. Parental consent for initial evaluation will not be construed as consent for initial provision of special education and related services.

B. The District will make reasonable efforts to obtain the informed consent from the parent for an initial evaluation. [34 C.F.R. 300.300]

For initial evaluations only, if the child is a ward of the state, is not residing with the child's parent, the District is not required to obtain consent from the parent if:

A. Despite reasonable efforts to do so, the District cannot discover the whereabouts of the parents of the child;

B. The rights of the parents of the child have been terminated in accordance with state law;

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C. The rights of the parent to make educational decisions have been subrogated by a judge, in accordance with state law, and consent for an initial evaluation has been given by an individual appointed by the judge to represent the child. [34 C.F.R. 300.300]

The District may, but is not required to seek informed consent through due process procedures if the parent of a child who is enrolled or seeking to enroll in the District refuses, or fails to respond to, a request to provide consent for an initial evaluation. [34 C.F.R. 300.300]

The District will obtain informed consent from the parent of the child before the initial provision of special education and related services to the child, and will make reasonable efforts to obtain that consent. [34 C.F.R. 300.300]

If a parent refuses consent for the initial provision of special education and related services, the District will not seek consent through due process hearing procedures. The District:

A. Will not be considered to be in violation to provide a Free Appropriate Public Education (FAPE);

B. Is not required to convene a IEP team meeting or develop an IEP for the child. [34 C.F.R. 300.300]

If, at any time subsequent to the initial provision of special education and related services, the parent of a child revokes consent in writing for the continued provision of special education and related services, the District:

A. May not continue to provide special education and related services to the child, but shall provide prior written notice before ceasing the provision of special education and related services;

B. May not use the mediation procedures or the due process procedures in order to obtain agreement or a ruling that the services may be provided to the child;

C. Will not be considered in violation of the requirement to make FAPE available to the child because of the failure to provide the child with further special education and related services; and

D. Is not required to convene an IEP Team meeting or develop an IEP for the child for further provision of special education and related services. If a parent revokes consent in writing for their child's receipt of special education services after the child is initially provided special education and related services, the District is not required to amend the child's education records to remove any reference to the child's receipt of special education and related services because of the revocation of consent.

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The District will obtain informed consent prior to conducting any reevaluation of a child with a disability.

A. If the parent refuses consent, the District may utilize due process hearing procedures to seek consent, but does not violate its obligation if it declines to pursue the evaluation or reevaluation.

B. The informed parental consent for reevaluation need not be obtained if the District can demonstrate that:

1. it made reasonable efforts to obtain such consent and has documented those attempts;

2. the child's parent has failed to respond. [34 C.F.R. 300.300]

Parental consent is not required before:

A. Reviewing existing data as part of an evaluation or reevaluation; or

B. Administering a test or other evaluation that is administered to all children unless consent is required of parents of all children prior to administration. [34 C.F.R. 300.300]

The District will not use a parent's refusal to consent to one service or activity under this section to deny the parent or child any other service, benefit, or activity of the District, except as required by this part. [34 C.F.R. 300.300]

If a parent of a child who is home-schooled or placed in a private school by the parents at their own expense does not provide consent for the initial evaluation or the reevaluation, or the parent fails to respond to a request to provide consent, the District will not utilize due process hearing procedures to seek consent. [34 C.F.R. 300.300]

Consistent with consent requirements of §300.300, either a parent of a child or the District may initiate a request for an initial evaluation to determine if a child is a child with a disability. [34 C.F.R. 300.301]

If the parent requests the evaluation, the District must, within a reasonable amount of time not to exceed fifteen (15) school days from the date it receives a parent's written request for an evaluation, either begin the evaluation by reviewing existing data or provide prior written notice refusing to conduct the requested evaluation. The sixty (60)-day evaluation period shall commence upon the District's receipt of the parent's informed written consent. [A.A.C. R7-2-401.E]

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The initial evaluation will:

A. Be conducted within sixty (60) calendar days of receiving informed written parental consent for the evaluation, unless: [34 C.F.R. 300.301] [A.A.C.R7-2-401(E)(3)]

1. the parents and the District agree, in writing, that it is in the best interest of the child to extend the timeline to complete the evaluation for an additional thirty (30) calendar days; or;

2. the child enrolls in the District following the child's departure from a previous district after the parent has provided consent and before the determination of eligibility by the child's previous district. In that event, the District ensures prompt completion of the evaluation.

3. the parent of a child with a disability repeatedly fails or refuses to produce the child for the evaluation.

B. Consist of procedures to determine if the child is a child with a disability and to determine the educational needs of the child. [34 C.F.R. 300.301] [A.A.C. R7-2-401.E]

C. The initial evaluation of a child being considered for special education or re-evaluation shall conclude with the date of the Multidisciplinary Evaluation Team (MET) determination of eligibility.

D. Neither the sixty (60)-day evaluation period nor any extension shall cause a re-evaluation to exceed the time-lines for a re-evaluation within three (3) years of the previous evaluation. [34 C.F.R. 300.301] [A.A.C. R7-2-401.E]

The District will conduct a reevaluation of a child with a disability if:

A. The District determines that the educational or related service needs, including improved academic achievement and functional performance, of the child warrant a reevaluation; or

B. If the child's parents or teacher requests a reevaluation; except

C. The District will not conduct a reevaluation more than once a year unless the parent and District agree otherwise. [34 C.F.R. 300.303]

The District will conduct a reevaluation at least once every three (3) years. The Multidisciplinary Evaluation Team shall determine, in accordance with IDEA and regulations, whether the requirements of subsections (E)(6)(a) through (i) are required for a student's re-evaluation. [34 C.F.R. 300.303] [A.A.C. R7-2-401.E]

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The District will provide prior written notice to the parents of a child who has, or who is suspected of having, a disability, that describes the evaluation procedures that the District proposes to conduct. [34 C.F.R. 300.304]

In conducting an evaluation or reevaluation, the District will:

A. Use a variety of assessment tools and strategies to gather relevant functional, developmental, and academic information about the child, including information provided by the parent in order to determine;

1. whether the child is a child with a disability; and

2. if the child is a child with a disability, information related to enabling the child to be involved in and progress in the general education curriculum (or for a preschool child, to participate in appropriate activities).

B. Not use any single measure or assessment as the sole criterion for determining whether a child is a child with a disability and for determining an appropriate educational program for the child; and

C. Use technically sound instruments that may assess the relative contribution of cognitive and behavioral factors, in addition to physical or developmental factors. [34 C.F.R. 300.304]

For the following disabilities, the full and individual initial evaluation shall include:

A. *Emotional disability*: verification of a disorder by a qualified professional.

B. *Hearing impairment*:

1. An audiological evaluation by a qualified professional, and

2. An evaluation of communication/language proficiency.

C. *Other health impairment*: verification of a health impairment by a qualified professional.

D. *Specific learning disability*: a determination of whether the child exhibits a pattern of strengths and weaknesses in performance, achievement, or both, relative to age, state-approved grade-level standards, or intellectual development that meets the District's criteria through one of the following:

1. A discrepancy between achievement and ability;

2. The child's response to scientific, research-based interventions; or

3. Other alternative research-based procedures.

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E. *Orthopedic impairment*: verification of the physical disability by a qualified professional.

F. *Speech/language impairment*: an evaluation by a qualified professional.

G. For students whose speech impairments appear to be limited to articulation, voice, or fluency problems, the written evaluation may be limited to:

1. An audiometric screening within the past calendar year,

2. A review of academic history and classroom functioning,

3. An assessment of speech problems by a speech therapist, or,

4. An assessment of the student's functional communication skills.

H. The Department of Education shall develop a list, subject to review and approval of the State Board of Education, of qualified professionals eligible to conduct the appropriate evaluations prescribed in A.A.C. R7-2-401.E.7.

The District ensures that evaluation materials and strategies:

A. Are selected and administered so as not to be discriminatory on a racial or cultural basis;

B. Are administered in the child's native language or other mode of communication and in the form most likely to yield accurate information on what the child knows and can do academically, developmentally, and functionally, unless it is clearly not feasible to do so;

C. Are used for the purposes for which the assessment(s) or measure(s) are valid and reliable;

D. Are administered by trained and knowledgeable personnel;

E. Are administered in accordance with the instructions provided by the assessment publisher;

F. Are selected and administered so as to ensure that if administered to a child with impaired sensory, manual, or speaking skills, the assessment results accurately reflect the child's aptitude or achievement level or whatever other factors the test purports to measure rather than reflecting the child's impairments (unless those skills are the factors being measured).

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G. Assess the child in all areas related to the suspected disability, including, if appropriate, health, vision, hearing, social and emotional status, general intelligence, academic performance, adaptive behavior, communicative status, and motor abilities; and

H. Are sufficiently comprehensive to identify all of the child's special education and related services needs, whether or not those needs are commonly associated with the child's disability.

I. Provide relevant information that directly assists in determining the educational needs of the child. [34 C.F.R. 300.304]

Evaluations of children who transfer to or from another District in the same school year are coordinated with the prior and subsequent schools, in order to expedite the completion of a full evaluation. [34 C.F.R. 300.304]

As part of an initial evaluation (if appropriate), and as part of any reevaluation, the IEP team and other qualified professionals, as appropriate, will:

A. Review existing evaluation data on the child including:

1. evaluations and information provided by the parents;

2. current classroom-based, local and state-wide assessments, and classroom-based observations;

3. observations by teachers, and related services providers.

B. On the basis of that review, and input from the child's parents, identify what additional data, if any, are needed to determine whether:

1. the child is or continues to be a child with a disability, and, if so, the educational needs of the child;

2. the present levels of academic achievement and related developmental needs of the child;

3. whether the child needs special education and related services to enable the child to meet measurable annual IEP goals and to participate, as appropriate, in the general education curriculum.

C. The IEP team may conduct the review without a meeting. [34 C.F.R. 300.305]

D. The District may accept current information about the student from another state, public agency, public education agency, or through an independent education evaluation.

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If additional data are needed, the District will administer the assessments required to obtain the additional data. [34 C.F.R. 300.305]

If additional data are not needed to determine whether the child continues to be a child with a disability, and to determine the child's educational needs, the District will notify the parents of:

A. The determination and the reasons for the determination; and

B. The right of the parents to request an assessment to determine whether the child continues to be a child with a disability and to determine the child's educational needs. [34 C.F.R. 300.305]

The District will evaluate a child before determining that the child is no longer a child with a disability except when the termination is due to graduation with a regular high school diploma or at the conclusion of the instructional year during which the child attained the age of twenty-two (22).

When the child's eligibility terminates because of graduation or at the conclusion of the instructional year during which the child attained the age of twenty-two (22), the District will provide a summary of the child's academic achievement and functional performance that includes recommendations on how to assist the child in meeting the child's postsecondary goals. [34 C.F.R. 300.305]

Upon completion of the evaluation process, the District ensures that:

A. A group of qualified professionals and the parent of the child determine:

1. if the child is a child with a disability under the Individuals with Disabilities Education Act, Arizona State Statutes, and Arizona Administrative Code; and

2. if so, the educational needs of the child.

B. The parents are provided, at no cost, a copy of the evaluation report and eligibility determination. [34 C.F.R. 300.306]

A child will not be determined to be a child with a disability if the primary factor for the determination is:

A. Lack of appropriate instruction in reading, including the essential components of reading instruction (as defined in 1208(3) of the Elementary and Secondary Education Act [ESEA]);

B. Lack of appropriate instruction in math; or

C. Limited English proficiency. [34 C.F.R. 300.306]

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The eligibility determination, including education needs, will be based on all of the information sources used in the evaluation process, and if deemed eligible and in need of special education and related services, an IEP will be developed in accordance with §300.320 through 300.324. [34 C.F.R. 300.306]

Additional procedures for identifying children with specific learning disabilities:

A. *Option 1*:

The District will use the state-adopted criteria for determining whether a child has a specific learning disability through a process based on the child's response to scientific, research-based intervention in conformity with IDEA Regulations §300.307-311. [34 C.F.R. 300.307]

B. *Option 2*:

The District will use a criteria for determining whether a child has a specific learning disability through the identification of a severe discrepancy between intellectual ability and achievement in conformity with IDEA Regulations §300.307-311. [34 C.F.R. 300.307]

C. *Option 3*:

The District will determine, on an individual child basis, the criteria for determining whether a child has a specific learning disability using one of the following criteria in conformity with IDEA Regulations §300.307-311:

a. The state-adopted criteria based on a child's response to scientific, research-based intervention;

b. The identification of a severe discrepancy between intellectual ability and achievement. [34 C.F.R. 300.307]

The determination of whether a child suspected of having a specific learning disability is a child with a disability will be made by the child's parents and a team of qualified professionals which will include:

A. The child's regular education teacher; or

B. If the child does not have a regular education teacher, then a regular education teacher qualified to teach children of that age;

C. For a child of less than school age, an individual qualified by the state to teach children of his/her age;

D. At least one (1) person qualified to conduct individual diagnostic evaluations of children, such as a school psychologist, speech-language pathologist, or remedial reading teacher. [34 C.F.R. 300.308]

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A child may be determined to have a specific learning disability if:

A. The child does not achieve adequately for the child's age or meet state-approved grade level standards in one (1) or more of the following areas, when provided with learning experiences and instruction appropriate for the child's age or meet state-approved grade level standards:

1. oral expression
2. listening comprehension
3. written expression
4. basic reading skill
5. reading fluency skills
6. reading comprehension
7. mathematics calculation
8. mathematics problem solving

B. The child does not make sufficient progress to meet age or state-approved grade level standards in one (1) or more of the areas listed immediately above when using a process based on the child's response to scientific, research-based intervention; or

C. The child exhibits a pattern of strengths and weaknesses in performance, achievement, or both, relative to age, state-approved grade level standards, or intellectual development, that is determined by the group to be relevant to the identification of a specific learning disability using appropriate assessments. [34 C.F.R. 300.309]

The findings of this section are not primarily the result of:

A. A visual, hearing or motor disability;

B. Intellectual disability;

C. Emotional disturbance;

D. Cultural factors;

E. Environmental or economic disadvantage; or

F. Limited English proficiency. [34 C.F.R. 300.309]

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The group ensures that the underachievement is not due to a lack of appropriate instruction in reading or math and consider:

A. Data that demonstrate that prior to, or as part of, the referral process, the child was provided appropriate instruction in regular education settings, delivered by qualified personnel; and

B. Data-based documentation of repeated assessments of achievement at reasonable intervals, reflecting formal assessment of student progress during instruction, which was provided to the child's parents. [34 C.F.R. 300.309]

The District will promptly request parent consent to evaluate if, prior to referral, the child has not made adequate progress after an appropriate period of time when provided instruction described in the two (2) immediately preceding bullets. [34 C.F.R. 300.309]

The District ensures that the child is observed in his/her learning environment, including the regular classroom setting, to document the child's academic performance and behavior in the areas of difficulty. [34 C.F.R. 300.310]

In the case of a child less than school age or out of school, a group member will observe the child in an environment appropriate for a child that age. [34 C.F.R. 300.310]

For a child suspected of having a specific learning disability, the eligibility determination will contain a statement of:

A. Whether the child has a specific learning disability;

B. The basis for making the determination, including an assurance the determination was made in accordance with the Individuals with Disabilities Education Act;

C. The relevant behavior, if any, noted during the observation and the relationship of that behavior to the child's academic functioning;

D. The educationally relevant medical findings, if any;

E. Whether the child does not achieve adequately for his/her age or to meet state-approved grade level standards consistent with whether the child has a specific learning disability; and does not make sufficient progress to meet age or state-approved grade level standards consistent with the basis of a determination in accordance with IDEA; or

F. The child exhibits a pattern of strengths and weaknesses in performance, achievement, or both, relative to age, state-approved grade level standards or intellectual development consistent with the observation of relevant behavior.

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G. The determination of the group concerning the effects of a visual, hearing, or motor disability; intellectual disability; emotional disturbance; cultural factors; environmental or economic disadvantage; or limited English proficiency of the child's achievement level. [34 C.F.R. 300.311]

If the child participated in a process that assessed the child's response to scientific, research-based intervention, the determination must include:

A. The instructional strategies used and the student-centered data collected; and

B. The documentation that the child's parents were notified about the state's policies regarding the amount and nature of student performance that would be collected and the general education services that would be provided;

C. Strategies for increasing the rate of learning; and

D. The parent's right to request an evaluation. [34 C.F.R. 300.311]

Each group member will certify in writing whether the report reflects the member's conclusion. If it does not, the group member will submit a separate statement presenting the member's conclusions. [34 C.F.R. 300.311]

The District shall establish, implement, and make available to school-based personnel and parents within its boundaries of responsibility written procedures for the initial full and individual evaluation of students suspected of having a disability, and for the reevaluation of students previously identified as being eligible for special education. [A.A.C. R7-2-401.E]

Procedures for the initial full and individual evaluation of children suspected of having a disability and for the reevaluation of students with disabilities shall meet the requirements of IDEA and its regulations, state statutes, and State Board of Education rules. [A.A.C. R7-2-401.E]

Free Appropriate Public Education

The determination that a child is eligible for special education and related services will be made on an individual basis by a properly constituted District team. [34 C.F.R. 300.306 and, if applicable, 300.308]

For preschool children (age three [3] to five [5]):

The District will:

1. Make FAPE available no later than the child's third birthday;

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2. Ensure that an IEP or an Individualized Family Service Plan (IFSP) is in effect for each child by that date;

3. Ensure that a child's IEP team determines the date when services under the IEP or IFSP will begin if a child's third birthday occurs during the summer.

For school-aged children (age five [5] through twenty-one [21]):

The District will make FAPE available to any child who needs special education and related services, even though the child has not failed or been retained in a course or grade, and is advancing from grade to grade. Services for an eligible student with a disability shall extend through conclusion of the instructional year during which the student attains the age of twenty-two (22).

The District will establish policy and procedures with regard to allowable pupil-teacher ratios and pupil-staff ratios within the District or county for provision of special education services. [A.R.S. 15-764.A(5)]

The special education programs and services established pursuant to this section and section 15-765 shall be conducted only in a school facility which houses regular education classes or in other facilities approved by the division of special education. [A.R.S. 15-764.B]

The District ensures that assistive technology devices or services or both will be available to a child with a disability, if required, as a part of:

A. special education;

B. related services;

C. supplementary aids and service. [34 C.F.R. 300.105]

On a case-by-case basis, the District ensures the use of school-purchased assistive technology devices in a child's home or other setting if the child's IEP team determines that the child needs access to those devices in order to receive FAPE. [34 C.F.R. 300.105]

The District will make extended school year services available as necessary to provide FAPE to children with disabilities.

A. Extended school year (ESY) services will be provided only if a child's IEP team determines, in accordance with §§300.320-300.324, that the services are necessary for the provision of FAPE.

B. Services will not be:

1. limited to a particular category of disability; or,

2. unilaterally limited to the type, amount, or duration of services. [34 C.F.R. 300.106]

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The ESY services that are provided to a child with a disability will:

A. Be provided beyond the normal school year of the District;

B. Be provided in accordance with the child's IEP;

C. Be provided at no cost to the parents of the child; and

D. Meet the standards of the state. [34 C.F.R. 300.106]

The District will afford children with disabilities an equal opportunity for participation in nonacademic and extracurricular services and activities including, as determined appropriate and necessary by the child's IEP team, the provision of supplementary aids and services. [34 C.F.R. 300.107]

Nonacademic and extracurricular services and activities may include counseling services, athletics, transportation, health services, recreational activities, special interest groups or clubs sponsored by the District, referrals to agencies that provide assistance to individuals with disabilities, and employment of students, including both employment by the District and assistance in making outside employment available. [34 C.F.R. 300.107]

The District will make regular physical education services available to children with disabilities to the same extent that the District provides those services to children without disabilities, unless:

A. The child is enrolled full time in a separate facility; or

B. The child needs specially designed physical education as prescribed in the child's IEP. [34 C.F.R. 300.108]

If a child is enrolled in a separate facility, the District ensures that the child receives appropriate physical education services. [34 C.F.R. 300.108]

If special physical education is prescribed in a child's IEP, the District will provide for those services, either directly or through other public or private programs. [34 C.F.R. 300.108]

The District ensures that children with disabilities have available to them the variety of education programs and services that are available to nondisabled children, including art, music, industrial arts, consumer and homemaking education, and vocational education. [34 C.F.R. 300.110]

When serving children wearing hearing aids or surgically implanted medical devices, the District ensures that:

A. The hearing aids worn in school by children with hearing impairments are functioning properly; and

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B. The external components of surgically implanted medical devices (e.g., cochlear implants) are functioning properly, except that the District will not be responsible for any post-surgical maintenance, programming or replacement of any component, external or internal, of the medical device. [34 C.F.R. 300.113]

The District may use the Medicaid or other public benefits or insurance programs in which a child participates to provide or pay for services required under IDEA, as permitted under the public benefits or insurance program, except that the District:

A. Will not require parents to sign up for or enroll in public benefits or insurance programs to receive FAPE;

B. Will not require parents to incur out-of-pocket expenses such as payment of a deductible or co-pay for services required by IDEA, but may pay the cost that parents otherwise would be required to pay;

C. Will not use a child's public benefit if that use would:

1. decrease lifetime benefits;

2. result in the family paying for non-school services that would otherwise be paid for by public benefits;

3. increase premiums or lead to discontinuation of benefits; or

4. risk loss of eligibility. [34 C.F.R. 300.154]

The District will notify parents that their refusal to allow access to their public benefits does not relieve the District of its responsibility to provide all required IDEA services. [34 C.F.R. 300.154]

The District will obtain a one (1)-time written consent from the parent, after providing written notification and prior to accessing a child's or parent's public benefits for the first time. The consent must specify:

A. The personally identifiable information that may be disclosed;

B. The purpose of the disclosure; and

C. The agency to which the disclosure may be made.

The District will provide a written notification to the child's parents before accessing the child's or parent's public benefits or insurance for the first time and prior to obtaining the one-time parental consent and annually thereafter.

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The District responsible for serving preschool children with disabilities shall establish, implement, and make available to its personnel and parents, written procedures for:

A. The operation of the preschool program, in accordance with federal statute and regulations and the state statutes, that provides a continuum of placements for students;

B. The smooth and effective transition from the Arizona Early Intervention Program to a public school preschool program in accordance with the agreement between the Department of Economic Security and the Department; and

C. The provision of a minimum of three hundred sixty (360) minutes per week of instruction in a program that meets at least two hundred sixteen (216) hours over the minimum. [A.A.C. R7-2-401.K]

The District shall establish, implement, and make available to its personnel and parents written procedures regarding the access to special education services to students enrolled in private schools by their parents as identified by the IDEA and its regulations, state statutes, and State Board of Education rules. [A.A.C. R7-2-401.F]

Graduation

The District ensures that the Governing Board shall prescribe graduation criteria for students with disabilities from its high schools, which shall include accomplishment of the academic standards in at least reading, writing, mathematics, science and social studies, as determined by District assessment. [A.R.S. 15-701(B) and A.A.C. R7-2-301(D)(1)]

The District ensures that the Governing Board shall develop a course of study and graduation and promotion requirements for all students placed in special education programs in accordance with R7-2-401 et seq. [A.R.S. 15-701(B) and A.A.C. R7-2-301(D)(1)]

The District will not be obligated to provide FAPE to students with disabilities who have graduated from high school with a regular high school diploma. [34 C.F.R. 300.102]

The exception does not apply to children who have graduated from high school but have not been awarded a regular high school diploma. [34 C.F.R. 300.102]

Parents shall be provided written notification of a student's anticipated graduation date at least one (1) year before the anticipated high school graduation date.

Graduation from high school with a regular high school diploma constitutes a change of placement requiring prior written notice in accordance with §300.503. [34 C.F.R. 300.102]

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An evaluation is not required before the termination of a child's eligibility due to graduation from secondary school with a regular diploma or due to conclusion of the instructional year during which the student attains the age of twenty-two (22). [34 C.F.R. 300.305]

For a child no longer eligible due to graduation or exceeding the age of eligibility, the District will provide the child with a summary of the child's academic achievement and functional performance, which shall include recommendations on how to assist the child in meeting the child's post secondary goals. [34 C.F.R. 300.305]

Pupils with disabilities as defined in A.R.S. 15-761 or children who receive special education as defined in 15-763, shall not be required to achieve passing scores on competency tests in order to graduate from high school unless the pupil is learning at a level appropriate for the pupil's grade level in a specific academic area and unless a passing score on a competency test is specifically required in a specific academic area by the pupil's IEP as mutually agreed on by the pupil's parents (or eighteen [18] year old student) and IEP team. [A.R.S. 15-701.01(3)]

Individualized Education Program

Each individualized education program (IEP) of a student with a disability shall be developed in accordance with IDEA and its regulations, state statutes, and State Board of Education rules. If appropriate to meet the needs of a student and to ensure access to the general curriculum, an IEP team may include specially designed instruction in the IEP that may be delivered in a variety of educational settings by a general education teacher or other certificated personnel provided that certificated special education personnel are involved in the planning, progress monitoring, and when appropriate, the delivery of the specially designed instruction. [A.A.C. R7-2-401.G]

Each student with a disability who has an IEP shall participate in the state assessment system. Students with disabilities can test with or without accommodations or modifications as indicated in the student's IEP. Students who are determined to have a significant cognitive disability based on the established eligibility criteria will be assessed with the state's alternate assessments as determined by the IEP team. [A.A.C. R7-2-401.G]

The contents of each individualized education program (IEP) will include a statement of:

A. The child's present levels of academic achievement and functional performance, including:

1. how the child's disability affects the child's involvement and progress in the general curriculum; or

2. for preschool children, as appropriate, how the disability affects the child's participation in appropriate activities;

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B. Measurable annual goals, including academic and functional goals designed to:

1. meet the child's needs that result from the child's disability to enable the child to be involved in and make progress in the general education curriculum; and

2. meet each of the child's other educational needs that result from the child's disability;

3. for children with disabilities who take alternate assessments aligned to alternate achievement standards, a description of benchmarks or short-term objectives;

C. How the child's progress toward meeting the IEP goals will be measured and when periodic reports on the child's progress toward the goals will be provided;

D. The special education and related services to be provided to the child, the supplementary aids and services to be provided to the child or on behalf of the child, the program modifications or supports for school personnel that will be provided to enable the child:

1. to advance appropriately toward attaining the annual goals;

2. to be involved in and progress in the general education curriculum and to participate in extracurricular and other nonacademic activities with other children with disabilities and nondisabled children.

E. If a child needs special education and related services because of a specific learning disability, the child's IEP shall indicate whether the child has been diagnosed with dyslexia;

F. ~~E.~~ The extent, if any, to which the child will not participate with nondisabled children in the regular class and in extracurricular and other nonacademic activities;

G. ~~F.~~ Any individual accommodations that are needed to measure the academic achievement and functional performance of the child on state and District-wide assessments;

H. ~~G.~~ If the IEP team determines that the child must take an alternate assessment instead of a particular regular state or District-wide assessment of student achievement, a statement of why:

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1. the child cannot participate in the regular assessment; and

2. the particular alternate assessment selected is appropriate for the child;

I. ~~H.~~ The projected date for the beginning of the services and modifications and the anticipated frequency, location, and duration of those services and modifications. [34 C.F.R. 300.320]

J. ~~I.~~ The student's estimated graduation date, aligned with the transition plan, by the end of ninth (9th) grade or age sixteen (16), whichever comes first, or earlier, if determined necessary by the student's IEP team.

Beginning not later than the first IEP to be in effect when the student turns sixteen (16), or earlier if determined appropriate by the IEP team, and updated annually, the IEP will also include a statement of:

A. appropriate measurable postsecondary goals based upon age-appropriate transition assessments related to training, education, employment, and, where appropriate independent living skills;

B. transition plan and services (including courses of study) needed to assist the child in reaching those goals by the anticipated graduation date. [34 C.F.R. 300.320]

Beginning not later than one (1) year before a student reaches the age of eighteen (18), the IEP will include a statement that the parents and the student have been informed of the rights under Part B, if any, that will transfer to the student on reaching the age of eighteen (18). [34 C.F.R. 300.320]

The IEP team for each child with a disability will include:

A. The parents of the child;

B. Not less than one (1) regular education teacher of the child (if the child is, or may be, participating in the regular education environment);

C. Not less than one (1) special education teacher of the child, or where appropriate, not less than one special education provider of the child;

D. A representative of the District who:

1. is qualified to provide, or supervise the provision of, specially designed instruction to meet the unique needs of children with disabilities;

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2. is knowledgeable about the general education curriculum; and

3. is knowledgeable about the availability of resources of the District;

4. may be a District team member described in the IEP team described above, with the exception of the parents, if the above criteria are met.

E. An individual who can interpret the instructional implications of evaluation results, who may be a member of the team described in the IEP team described above.

F. At the discretion of the parent or the District, other individuals who have knowledge or special expertise regarding the child, including related services personnel as appropriate; and

G. Whenever appropriate, the child with a disability.

1. A child of any age if the purpose of the meeting is to consider postsecondary goals and transition services needed to assist the child in reaching the IEP goals;

2. If the student does not attend the IEP meeting, the District will take other steps to ensure that the student's preferences and interests are considered.

H. To the extent appropriate and with consent of the parents or the adult child, the District will invite a representative of any participating agency that is likely to be responsible for providing or paying for transition services.

I. For a child who is transitioning from the Arizona Early Intervention Program (AzEIP), representatives from AzEIP must be invited to the initial IEP if the parent requests. [34 C.F.R. 300.321]

A member of the IEP team described above is not required to attend the IEP meeting if the parent and the school agree in writing prior to the meeting that attendance is not necessary because the member's area of curriculum or related services is not being modified or discussed in the meeting. [34 C.F.R. 300.321]

A member of the District IEP team described above, and including a person who can interpret the results, may be excused from attending the IEP meeting in whole or part when the meeting involves a modification to or discussion of the member's area of the curriculum or related services if the parent, in writing and the District consent to the excusal, and the member submits, in writing to the IEP team, input into the development of the IEP prior to the meeting. [34 C.F.R. 300.321]

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A parent or the District may request in writing a review of the IEP and shall identify the basis for requesting review. Such review shall take place within forty-five (45) school days of the receipt of the request at a mutually agreed upon date and time. [A.A.C. R7-2-401.G]

In the case of a child previously served by AzEIP, an invitation to the initial IEP team meeting will, at the request of the parent, be sent to the AzEIP service coordinator to assist with the smooth transition of services. [34 C.F.R. 300.321]

The District will take steps to ensure parent(s) of a child with a disability are present at each IEP meeting or are afforded the opportunity to participate by:

A. Notifying parents of the meeting early enough to ensure that they will have an opportunity to attend; and

B. Scheduling the meeting at a mutually agreed on time and place. [34 C.F.R. 300.322]

The meeting notice will:

A. Indicate the purpose, time, and location of the meeting and who will be in attendance; and

B. Inform the parents of the provisions relating to the participation of other individuals who have knowledge or special expertise about the child and of representatives of the AzEIP if the meeting is for an initial IEP of a child transitioning from AzEIP. [34 C.F.R. 300.322]

Beginning not later than the first IEP to be in effect by the end of ninth (9th) grade or age sixteen (16), whichever comes first, or earlier, if determined necessary by the student's IEP team, the notice will also:

A. Indicate that a purpose of the meeting will be the consideration of postsecondary goals and transition services;

B. Indicate that the District will invite the student;

C. Identify any other agency that will be invited to send a representative. [34 C.F.R. 300.322]

If neither parent can attend, the District will use other methods to ensure parent participation, including individual or conference telephone calls. [34 C.F.R. 300.322]

A meeting may be conducted without a parent in attendance if the District is unable to convince the parents that they should attend. In this case, the District will maintain a record of its attempts to arrange a mutually agreed on time and place, such as:

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A. Detailed records of telephone calls made or attempted and the results of those calls;

B. Copies of correspondence sent to the parents and any responses received; and

C. Detailed records of visits made to the parent's home or place of employment and the results of those visits. [34 C.F.R. 300.322]

The District will take whatever action is necessary to help the parent understand the proceedings at the IEP meeting, including arranging for an interpreter for parents with deafness or whose native language is other than English. [34 C.F.R. 300.322]

The District will give the parent a copy of the child's IEP at no cost to the parent. [34 C.F.R. 300.322]

At the beginning of each school year, the District will have in effect for each child with a disability in its jurisdiction, an IEP as defined in 300.320. [34 C.F.R. 300.323]

The District ensures that:

A. A meeting to develop an IEP for an eligible child is conducted within thirty (30) calendar days of a determination of eligibility for special education and related services.

B. As soon as possible following the development of the IEP, the services indicated in the IEP are made available to the child. An IEP will be in effect at the beginning of each school year. [34 C.F.R. 300.323]

For a child aged two (2) years nine (9) months to five (5) years previously served by AzEIP, the IEP team will consider the contents of the child's Individualized Family Service Plan (IFSP). An IFSP may serve as the IEP of the child if:

A. The District has provided the parents with a detailed explanation of the differences between an IEP and an IFSP;

B. The parent and the District agree in writing to the use of an IFSP;

C. The IFSP contains an educational component that promotes school readiness and includes pre-literacy, language and numeric skills; and

D. The IFSP is developed in accordance with IEP procedures. [34 C.F.R. 300.323]

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The District ensures that each child's IEP is accessible to each regular education teacher, special education teacher, related service provider and any other service provider who is responsible for implementing the IEP.

A. Each teacher and related service provider will be informed of his or her specific responsibilities in implementing the IEP; and

B. The specific accommodations, modifications, and supports that will be provided for the child in accordance with the IEP. [34 C.F.R. 300.323]

For a child with an IEP who transfers into the District from another school system in Arizona, the District, in consultation with the parents, will provide a free appropriate public education (including services comparable to the services described in the existing IEP) until the District:

A. Reviews and adopts the child's IEP from the previous district, or

B. Develops, adopts, and implements a new IEP. [34 C.F.R. 300.323]

For a child with an IEP who transfers into the District from another state, the District, in consultation with the parents, will provide a free appropriate public education (including services comparable to the services described in the existing IEP) until the District:

A. Conducts an evaluation for eligibility for special education in Arizona, or determines that such an evaluation is unnecessary; and

B. Develops, adopts, and implements a new IEP, if appropriate. [34 C.F.R. 300.323]

To facilitate the transition of a child enrolling from another school system, either from within or from outside of Arizona, the District will take reasonable steps to promptly obtain the child's education records, including all records pertaining to special education, from the previous school system in which the child was enrolled. [34 C.F.R. 300.323]

When a records request is received from another district, from either within or outside of Arizona, the District will promptly respond to the request. [34 C.F.R. 300.323]

In developing each child's IEP, the IEP team will consider:

A. The strengths of the child and the concerns of the parents for enhancing the education of their child;

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B. The results of the initial or most recent evaluation of the child; and

C. The academic, developmental, and functional needs of the child. [34 C.F.R. 300.324]

In consideration of special factors, the IEP team will:

A. In the case of a child whose behavior impedes his or her learning or that of others, consider the use of positive behavioral interventions and supports, and other strategies to address that behavior;

B. In the case of a child with limited English proficiency, consider the language needs of the child as those needs relate to the child's IEP;

C. In the case of a child who is blind or visually impaired, provide for instruction in Braille and the use of Braille unless the IEP team determines, after an evaluation of the child's reading and writing skills, needs, and appropriate reading and writing media (including an evaluation of the child's future needs for instruction in Braille or the use of Braille) that instruction in Braille or the use of Braille is not appropriate for the child;

D. Consider the communication needs of the child, and in the case of a child who is deaf or hard of hearing, consider the child's language and communication needs, opportunities for direct communication with peers and professional personnel in the child's language and communication mode, academic level and full range of needs, including opportunities for direct instruction in the child's language and communication mode;

E. Consider whether the child requires assistive technology devices and services. [34 C.F.R. 300.324]

The regular education teacher of a child with a disability, as a member of the IEP team, will, to the extent appropriate, participate in the development, review, and revision of the child's IEP, including the determination of:

A. Appropriate positive behavioral interventions and strategies for the child; and

B. Supplementary aids and services, program modifications, and/or supports for school personnel that will be provided for the child, consistent with §300.320(a)(4). [34 C.F.R. 300.324]

In making changes to the IEP after the annual IEP meeting, the parent and the District may agree to amend the IEP without a meeting for the purpose of making those changes and, instead, develop a written document to amend or modify the child's current IEP. The District will:

A. Inform all members of the child's IEP team of those changes, and

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B. Upon request, provide the parents with the revised copy of the IEP. [34 C.F.R. 300.324]

To the extent possible, the District will encourage the consolidation of evaluation, reevaluation and IEP meetings for a child. [34 C.F.R. 300.324]

The District ensures that the IEP team reviews the child's IEP periodically, but not less than annually, to determine if goals are being achieved, and revise the IEP, when appropriate, to address:

A. any lack of expected progress toward the annual goals and in the general education curriculum, if appropriate;

B. the results of any reevaluation;

C. information about the child provided to, or by the parents;

D. the child's anticipated needs, or other matters. [34 C.F.R. 300.324]

If a participating agency other than the District fails to provide the transition services in an IEP, the District will reconvene the IEP team to identify alternative strategies to meet the child's transition outcomes. [34 C.F.R. 300.324]

Before the District places a child with a disability in a private school or facility, the District will initiate and conduct a meeting to develop an IEP for the child and ensure that a representative of the private school or facility attends the meeting in person or by conference call. [34 C.F.R. 300.325]

Subsequent IEP reviews may be initiated and conducted by the private school at the discretion of the District. However, the District ensures that:

A. The parents and District representative are involved in any decisions about the child's IEP; and

B. They agree to any proposed changes in the IEP before those changes are implemented. [34 C.F.R. 300.325]

The District remains responsible to ensure FAPE to a child placed by the District in a private school or facility. [34 C.F.R. 300.325]

The District ensures that the parents of a child with a disability are members of any group that makes decisions on the educational placement of their child. [34 C.F.R. 300.327]

The District shall establish, implement, and make available to its school-based personnel and parents written procedures for the development, implementation, review, and revision of IEPs. [A.A.C. R7-2-401.G]

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Procedures for IEPs shall meet the requirements of the IDEA and its regulations, the state statutes, and the State Board of Education rules. [A.A.C. R7-2-401.G]

Procedures shall include the incorporation of Arizona academic standards as adopted by the State Board of Education into the development of each IEP and address grade-level expectations and grade-level content instruction. [A.A.C. R7-2-401.G]

Least Restrictive Environment

The District ensures that special classes, separate schooling, or other removal of children with disabilities from the regular educational environment occurs only if the nature or severity of the disability is such that education in regular classes with the use of supplementary aids and services cannot be achieved satisfactorily. [34 C.F.R 300.114]

The District will make available a continuum of alternative placements to meet the needs of children with disabilities for special education and related services. [34 C.F.R 300.115]

The continuum of alternative placements will include:

A. Instruction in regular classes, special classes, special schools, home instruction, and instruction in hospital and institutions;

B. Supplementary services, such as a resource room or itinerant instruction, to be provided in conjunction with regular class placement.

The placement decision for each child will be:

A. Made by a group that includes the parents and other persons knowledgeable about the child, the meaning of the evaluation data, and the placement options;

B. In conformity with the least restrictive environment (LRE) provisions of the IDEA regulations;

C. Determined at least annually;

D. Based on the child's IEP; and,

E. As close as possible to the child's home. [34 C.F.R 300.115]

Unless the IEP of a child requires some other arrangement, the child will be educated in the school that he or she would attend if not disabled. [34 C.F.R 300.115]

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In selecting the LRE, consideration will be given to any potential harmful effect on the child or on the quality of services that she/he needs. [34 C.F.R 300.115]

A child with a disability will not be removed from age-appropriate regular classrooms solely because of needed modifications in the general education curriculum. [34 C.F.R 300.115]

In providing or arranging for the provision of nonacademic and extracurricular services and activities, including meals, recess periods, and other nonacademic activities, the District ensures that each child with a disability participates with nondisabled children in the extracurricular services and activities to the maximum extent appropriate to the needs of that child. [34 C.F.R 300.117]

The District ensures that the supplementary aides and services determined by the IEP team to be appropriate and necessary are provided to allow the child to participate in nonacademic settings. [34 C.F.R 300.115]

The District shall establish, implement, and make available to its school-based personnel and parents, written procedures to ensure the delivery of special education services in the least restrictive environment as identified by IDEA and its regulations, the state statutes, and the State Board of Education rules. [A.A.C. R7-2-401.H]

A continuum of services and supports for students with disabilities shall be available through the District. [A.A.C. R7-2-401.H]

Procedural Safeguards

The District ensures that the parents of a child with a disability shall be given an opportunity to inspect and review all education records with respect to the identification, evaluation, educational placement, and the provision of FAPE to the child. [34 C.F.R. 300.501]

The District ensures that the parents of a child with a disability shall:

A. be given an opportunity to participate in meetings with respect to the identification, evaluation, educational placement and the provision of FAPE to the child.

B. be provided notice consistent with §300.322 to ensure they have opportunity to participate in meetings.

C. be members of any group that makes decisions on the educational placement of their child. [34 C.F.R. 300.501]

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If neither parent can participate in a meeting in which a decision is to be made relating to the educational placement of their child, the District must use other methods to ensure their participation, including individual or conference telephone calls, or video conferencing. [34 C.F.R. 300.501]

A placement decision may be made by a group without the involvement of the parent, if the District is unable to obtain the parent's participation and has maintained a record of its attempts to ensure their involvement. [34 C.F.R. 300.501]

The parents of a child with a disability have the right to obtain an independent educational evaluation of their child. The District must provide to parents, upon request for an independent educational evaluation:

A. Information about where an independent educational evaluation may be obtained; and

B. The District criteria applicable for independent educational evaluations. District criteria for the independent educational evaluation must be the same as the criteria the District uses when it conducts an evaluation, to the extent consistent with the parent's right to an evaluation. [34 C.F.R. 300.502]

A parent has the right to an independent educational evaluation at public expense if the parent disagrees with an evaluation obtained by the District. If a parent requests an independent educational evaluation at public expense, the District must, without unnecessary delay, either:

A. File for a due process hearing to show that its evaluation is appropriate; or

B. Ensure that an independent educational evaluation is provided at public expense, unless the District demonstrates in a hearing that the evaluation obtained by the parent did not meet District criteria. [34 C.F.R. 300.502]

If a due process hearing decision is that the District's evaluation is appropriate, the parent still has the right to an independent educational evaluation, but not at public expense. [34 C.F.R. 300.502]

If a parent requests an independent educational evaluation, the District may ask for the parent's reasons for the objections, but may not require the parent to provide an explanation and may not unreasonably delay either providing the independent educational evaluation at public expense or filing a request for due process to defend its evaluation. [34 C.F.R. 300.502]

A parent is entitled to only one (1) independent educational evaluation at public expense each time the District conducts an evaluation with which the parent disagrees. [34 C.F.R. 300.502]

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The results of any independent educational evaluation which is obtained by or provided to the District:

A. Must be considered by the District, if it meets District criteria, in any decision with respect to the provision of FAPE to the child; and

B. May be presented by any party as evidence in a due process hearing. [34 C.F.R. 300.502]

If a hearing officer requests an independent educational evaluation as part of a due process hearing, the cost of the evaluation must be at public expense.

Written notice must be given to the parents of a child with a disability a reasonable time after the District:

A. Proposes to initiate or change the identification, evaluation or educational placement of the child or the provision of FAPE to the child; or

B. Refuses to initiate or change the identification, evaluation or educational placement of the child or the provision of FAPE to the child. [34 C.F.R. 300.503]

Such notice shall occur before the proposal or refusal action is implemented.

The notice must include:

A. A description of the action proposed or refused by the District;

B. An explanation of why the District proposes or refuses to take the action;

C. A description of each evaluation procedure, assessment, record or report the District used as a basis for the proposed or refused action;

D. A statement that the parents of a child with a disability have protection under the procedural safeguards of this part and, if this notice is not an initial referral for evaluation, the means by which a copy of a description of the procedural safeguards can be obtained;

E. Sources for parents to contact to obtain assistance in understanding the provisions of this part;

F. A description of other options that the IEP team considered and the reasons why those options were rejected;

G. A description of other factors that are relevant to the District's proposal or refusal. [34 C.F.R. 300.503]

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The notice must be written in language understandable to the general public, provided in the native language or other mode of communication used by the parent. [34 C.F.R. 300.503]

If the native language or other mode of communication used by the parent is not a written language, the District ensures:

A. The notice is translated orally or by other means to the parent in his or her native language or other mode of communication;

B. That the parent understands the content of the notice;

C. That there is written evidence of these requirements. [34 C.F.R. 300.503]

A copy of the procedural safeguards available to the parent of a child with a disability must be given to the parents only one (1) time a school year, except that a copy also must be given to the parents:

A. Upon initial referral or parent request for evaluation;

B. Upon receipt of a first complaint to the state or first request for a due process hearing in a school year;

C. When a disciplinary change of placement /removal has been initiated;

D. Upon request by a parent. [34 C.F.R. 300.504]

The procedural safeguards notice must include a full explanation of all the procedural safeguards available under §300.148, §§300.151 through 300.153, §300.300, §§300.502 through 300.503, §§300.505 through 300.515, §300.520, §§300.530 through 536, and §§300.610 through 300.625 relating to:

A. Independent educational evaluations;

B. Prior written notice;

C. Parental consent;

D. Access to education records;

E. Opportunity to present and resolve complaints through the due process hearing and state complaint procedures, including;

1. The time period in which to file a complaint;

2. The opportunity for the District to resolve the complaint;

3. The difference between due process hearing and state complaint procedures, jurisdictions, issues that may be raised, timelines, and relevant procedures.

F. The availability of mediation;

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G. The child's placement during the due process hearing;

H. Procedures for students subject to placement in an interim alternative educational setting;

I. Requirements for unilateral placements by parents of children in private schools at public expense;

J. Due process hearings including requirements for disclosure of evaluation results and recommendations;

K. Civil actions, including timelines;

L. Attorney fees. [34 C.F.R. 300.504]

This notice must meet the same requirements for understandable language as for the written prior notice described in §300.503. [34 C.F.R. 300.504]

The parent of a child with a disability may elect to receive required notices by an electronic mail communication if the District makes that option available. [34 C.F.R. 300.505]

The District will establish procedures to allow parties to disputes, including those matters arising prior to a request for a due process hearing, to resolve disputes through mediation. Procedures will ensure that the mediation process:

A. Is voluntary on the part of the parties;

B. Is not used to deny or delay a parent's right to a due process hearing or any other right under the IDEA;

C. Is conducted by a qualified and impartial mediator who is trained in effective mediation techniques. [34 C.F.R. 300.506]

The District may establish procedures to offer to parents and schools that choose not to use mediation an opportunity to meet, at a time and location convenient to the parties, with a disinterested party:

A. Who is under contract with an appropriate alternative dispute resolution entity, or a parent training and information center, or community parent resource center;

B. Who would explain the benefits of, and encourage the mediation process to the parents. [34 C.F.R. 300.506]

A parent or District may file a request for a due process hearing relating to the identification, evaluation or educational placement of a child with a disability. [34 C.F.R. 300.507]

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The request for a due process hearing must allege a violation that occurred not more than two (2) years before the date the parent or District knew or should have known about the alleged violation. [34 C.F.R. 300.507]

The District must inform the parent of any free or low cost legal and other relevant services available in the area upon parent request. [34 C.F.R. 300.507]

The District will have procedures that require either party, or the attorney representing a party, to provide to the other party a confidential due process complaint. [34 C.F.R. 300.508]

The party filing the notice for a hearing must forward a copy of the request to the state. [34 C.F.R. 300.508]

The due process hearing complaint must include the following in order for the complaint to be heard:

A. The name of the child;

B. The residential address of the child;

C. The school of attendance;

D. A description of the nature of the problem of the child relating to the proposed or refused initiation or change, including facts relating to the problem; and

E. A proposed resolution of the problem to the extent known and available to the party at the time. [34 C.F.R. 300.508]

The due process complaint will be deemed sufficient unless the party receiving the complaint notifies the hearing officer and the other party in writing, within fifteen (15) days of receipt of the complaint, that it believes the complaint does not meet the content requirements. [34 C.F.R. 300.508]

Within five (5) days of receipt of notice, the hearing officer must determine whether the complaint meets the requirements and notify the parties, in writing, of that determination. [34 C.F.R. 300.508]

A party may amend its due process complaint only if:

A. The other party consents in writing and is given an opportunity to resolve the complaint through the resolution process; or

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B. The hearing officer grants permission, but in no case later than five (5) days before the due process hearing begins. [34 C.F.R. 300.508]

If a party files an amended complaint, the relevant timelines begin again. [34 C.F.R. 300.508]

If the District has not sent a prior written notice to the parent regarding the subject matter contained in the due process complaint, it must do so within ten (10) days of receiving the complaint. [34 C.F.R. 300.508]

Within ten (10) days of receiving the complaint, the receiving party will send to the other party a response that specifically addresses the issues raised in the due process complaint. [34 C.F.R. 300.508]

Within fifteen (15) days of receiving the notice of the parent's due process complaint, and prior to the initiation of a due process hearing, the District must convene a meeting with the parent and the relevant members of the IEP team who have specific knowledge of the facts identified in the complaint that:

A. Includes a representative of the District who has District decision-making authority;

B. May not include an attorney of the District unless the parent is accompanied by an attorney. [34 C.F.R. 300.510]

The purpose of the meeting is for the parent of the child to discuss the due process complaint, and the factual basis of the complaint, so the District has the opportunity to resolve the dispute. [34 C.F.R. 300.510]

The resolution meeting need not be held if:

A. The parent and District agree in writing to waive the meeting; or

B. The parent and District agree to use the mediation process. [34 C.F.R. 300.510]

The parent and the District determine the relevant IEP team members to attend the meeting. [34 C.F.R. 300.510]

If the District has not resolved the complaint to the satisfaction of the parent within thirty (30) days of the receipt of the complaint, the due process hearing may occur. The timeline for issuing a final decision begins at the end of this thirty (30) day period. [34 C.F.R. 300.510]

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The failure of the parent to participate in the resolution meeting that has not been mutually agreed to be waived, will delay the timelines for the resolution process and due process hearing until the meeting is held. [34 C.F.R. 300.510]

If the District is unable to obtain the participation of the parent after reasonable efforts have been made and documented, the District may, at the conclusion of the thirty (30) day period, request the hearing officer dismiss the parent's due process complaint. [34 C.F.R. 300.510]

If the District fails to hold the resolution meeting within fifteen (15) days of receiving the complaint or fails to participate in the meeting, the parent may request that the hearing officer begin the hearing timeline. [34 C.F.R. 300.510]

The forty-five (45) day timeline for the due process hearing starts the day after:

A. Both parties agree in writing to waive the resolution meeting; or

B. After either the mediation or resolution meeting starts but before the end of the thirty (30) day resolution period, the parties agree in writing that no agreement is possible; or

C. If both parties agree in writing to continue the mediation at the end of the thirty (30) day resolution period, but later, one (1) party withdraws from the mediation process. [34 C.F.R. 300.510]

If a resolution is reached at the meeting, the parties must execute a legally binding agreement that is:

A. Signed by both the parent and District representative who has authority to legally bind the District; and

B. Enforceable in any state court of competent jurisdiction or in a district court of the United States. [34 C.F.R. 300.510]

Either party may void the agreement within three (3) business days of the agreement's execution. [34 C.F.R. 300.510]

The child involved in the due process hearing complaint must remain in his or her current educational placement:

A. Unless a discipline appeal has been filed as provided in §300.533;

B. During the pendency of any administrative or judicial proceeding regarding a due process complaint notice requesting a due process hearing under §300.507; or

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C. Unless the District and parents of the child agree otherwise. [34 C.F.R. 300.518]

If the complaint involves an application for initial admission to public school, the child, with the consent of the parents, must be placed in the public school until the completion of all the proceedings. [34 C.F.R. 300.518]

If the complaint involves an application for initial services for a child who has turned three (3) and transitioning from Part C to Part B, the District is not required to provide the Part C services the child had been receiving. If the child is found eligible for special education and related services under Part B, and the parent consents to the initial provision of services under §300.300(b), then the District must provide those services that are not in dispute. [34 C.F.R. 300.518]

If the hearing officer agrees with the child's parents that a change of placement is appropriate, that placement must be treated as an agreement between the state and parent for the purposes of (1)(c) of this section. [34 C.F.R. 300.518]

The District ensures that the rights of a child are protected by assigning an individual to act as a surrogate for the parents when:

A. No parent can be identified;

B. After reasonable efforts are made, no parent can be located;

C. The child is a ward of the state (with no foster parent);

D. The child is an unaccompanied homeless youth as defined by the McKinney-Vento Homeless Assistance Act. [34 C.F.R. 300.519]

The District will have a method for determining when a surrogate parent is needed and for making surrogate parent assignments. [34 C.F.R. 300.519]

The District ensures that a person selected as a surrogate parent:

A. Is not an employee of the state, the District, or any other agency that is involved in the education or care of the child;

B. Has no personal or professional interest that conflicts with the interest of the child the surrogate parent represents; and

C. Has knowledge and skills that ensure adequate representation of the child. [34 C.F.R. 300.519]

In the case of an unaccompanied homeless youth, appropriate staff of emergency shelters, transitional shelters, independent living programs, and street outreach programs may be appointed as temporary surrogate parents until a surrogate parent can be appointed that meets all the requirements of this section. [34 C.F.R. 300.519]

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When a child with a disability reaches age eighteen (18), unless that child has been determined to be incompetent:

A. The District will provide any notice required by the IDEA regulations to both the child and the parents; and

B. All rights accorded to parents under Part B of the Act transfer to the child. [34 C.F.R. 300.520]

When the rights are transferred, the District will provide notice to the child and parent of the transfer of rights. [34 C.F.R. 300.520]

The District shall establish, implement, and make available to school-based personnel and parents of students with disabilities written procedures to ensure children with disabilities and their parents are afforded the procedural safeguards required by federal statute and regulation and state statute. These procedures shall include dissemination of information to parents about the District's and the state's dispute resolution options. [A.A.C. R7-2-401.I]

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REGULATION

PROMOTION AND RETENTION OF STUDENTS

Competency Requirements for Promotion of Students from Third Grade

The District shall identify each student who is at risk of reading below grade level in kindergarten and grades one (1), two (2), and three (3). The District shall provide an annual specific written notification to parents or guardians of students in kindergarten programs and first (1st), second (2nd) and third (3rd) grades that a student who obtains a score on the reading portion of the state-wide assessment that does not demonstrate sufficient reading skills as established by the Board will not be promoted from the third (3rd) grade.

If the student's school has determined that the student is substantially deficient in reading before the end of grade three (3), the District shall provide to the parent or guardian of that student a specific written notification of the reading deficiency within three (3) weeks after identifying the reading deficiency. That notification shall include the following information:

A. A Description of the student's specific individual needs.

B. A description of the current reading services provided to the student.

C. A description of the available supplemental instructional services and supporting programs that are designed to remediate reading deficiencies. The District shall offer more than one (1) evidence-based intervention strategy and more than one (1) remedial strategy developed by the State Board of Education for students with reading deficiencies. The notification shall list the intervention and remedial strategies offered and shall instruct the parent or guardian to choose, in consultation with the student's teacher, the most appropriate strategies that will be implemented for the student.

D. Parental/guardian strategies to assist the student to attain reading proficiency.

E. The frequency with which the school district or charter school will provide timely updates and information to the parent on the student's progress toward reading proficiency.

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F. A ~~statement~~ requirement that ~~the~~ a student ~~will~~ not be promoted from the third (3rd) grade if the student ~~obtains a score on the reading portion of the state-wide assessment that~~ does not demonstrate~~s the student is~~ sufficient reading skills ~~far below the third-grade level does not demonstrate sufficient reading skills, unless the student is exempt from mandatory retention in grade three or the student qualifies for an exemption~~ as established by the State Board. A student who is not retained and who obtains a reading score on the state assessment that does not demonstrate sufficient reading skills must receive evidence-based intervention and remedial strategies.

G. A description of the District policies on midyear promotion to a higher grade.

Competency requirements for the promotion of a student from the third (3rd) grade shall include the following:

A. The student shall not be promoted from the third (3rd) grade if the student obtains a score on the reading portion of the state-wide assessment required test that does not demonstrate sufficient reading skills as established by the Board, unless the student is exempt from mandated retention or the student qualifies for an exemption as determined by the Governing Board.

B. The Governing Board may promote from the third (3rd) grade a student who does not demonstrate sufficient reading skills if the student:

1. is an English learner or a limited proficient student as defined in section 15-751 and has had fewer than two (2) years of English language instruction.

2. is in the process of a special education referral or evaluation for placement in special education or a student who has been diagnosed as having a significant reading impairment, including dyslexia or is a child with a disability as defined in section 15-761 if the student's individualized education program team and the student's parent or guardian agree that promotion is appropriate based on the student's individualized education program. "Dyslexia" as defined in section 15-701 means a brain-based learning difference that impairs a person's ability to read and spell, that is independent of intelligence and that typically causes a person to read at levels lower than expected.

3. has demonstrated or subsequently demonstrates sufficient reading skills or adequate progress towards sufficient reading skills of the third-grade reading standards as evidenced through a collection of reading assessments approved by the State Board of Education, which includes an alternative standardized reading assessment approved by the State Board.

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4. receives intervention and remedial services during the summer or subsequent school year pursuant to those indicated below under "Intervention and Remedial Strategies Developed by the State Board of Education" and demonstrates sufficient progress based on guidelines issued pursuant to the description of the school district or charter school policies on midyear promotion to a higher grade.

C. The student has demonstrated reading proficiency on an alternate assessment approved by the State Board of Education (SBE).

A student may not be retained if data regarding the student's performance on the state-wide assessment is not available before the end of the current academic year. A student who is not retained due to the unavailability of test data must receive evidence-based intervention and remedial strategies as in the section immediately below if the third-grade assessment data subsequently does not demonstrate sufficient reading skills.

Intervention and Remedial Strategies Developed by the State Board of Education (SBE) for Students Who Are Not Promoted from the Third Grade

The Governing Board shall offer more than one (1) of the intervention and remedial strategies developed by the SBE. The parent or guardian of a student not promoted from the third (3rd) grade and the student's teacher(s) and principal may choose the most appropriate intervention and remedial strategies that will be provided to that student. The intervention and remedial strategies developed by the SBE shall include:

A. A requirement the student be assigned for evidence-based reading instruction by a different teacher who was designated in that teacher's most recent performance evaluation in one (1) of the top two (2) performance classifications pursuant to section 15-203.

B. Summer school reading instruction.

C. Intensive reading instruction in the next academic year that occurs before, during, or after the regular school day, or any combination of before, during and after the regular school day.

D. Small group and teacher-led evidence-based reading instruction, which may include computer-based or online reading instruction.

E. A requirement that a school district governing board or charter school governing body that promotes a student pursuant to the above provide annual reporting to the Department of Education on or before October 1 that includes information on the total number of students subject to the retention provisions of Policy IKE and this regulation, the total number of students promoted pursuant to Policy IKE and this regulation, the total number of students retained in grade three (3) and the interventions administered.

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The intervention and remedial strategies developed by the SBE shall also:

A. Provide for universal screening of students in preschool programs, kindergarten programs and grades one (1) through three (3) that is designed to identify students who have reading deficiencies in accordance with A.R.S. 15-704.

B. Develop interventions and remedial strategies for students in kindergarten programs and grades one (1) through three (3) who are identified as having reading deficiencies pursuant to section 15-704.

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GRADUATION REQUIREMENTS

Regular Education

A minimum number of units of credit are required for graduation by the Arizona State Board of Education. Listed below are the units that must be completed before a student may receive a high school diploma.

Graduation requirements may be met as follows:

A. By successful completion of subject area course requirements.

B. By mastery of the standards adopted by the State Board of Education and other competency requirements for the subject as determined by the Governing Board in accord with A.A.C. R7-2-302 and rules established by the Superintendent.

C. By earning credits through correspondence courses (limited to one [1] in each of the four [4] major subject areas) and/or by passing appropriate courses at the college or university level if the courses are determined to meet standards and criteria established by the Board and in accord with A.R.S. 15-701.01.

D. By the transfer of credits as described in Policy JFABC.

E. An out-of-state transfer student is not required to pass the competency test to graduate if the student has successfully passed a statewide assessment test on state adopted standards that are substantially equivalent to the State Board Adopted Academic Standards.

Graduation requirements as determined by the Arizona State Board of Education (A.A.C. R7-2-302) and the District Governing Board are as follows:

English		4.0 units
Math		4.0 units*
Science		3.0 units**
Social Studies		3.0 units***
American Government and Arizona Government	0.5 unit	
American History - including Arizona History	1.0 unit	
World History and Geography – including instruction on the Holocaust and other genocides for at least three (3) class periods, or the equivalent, on at least two (2) separate occasions during any of grades seven through twelve (7-12).	1.0 unit	
Economics	0.5 unit****	
Fine Arts or Career, Technical and Vocational Education		1.0 unit
Electives		7.0 units
Total		22.0 units

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* In lieu of one (1) credit of Algebra II or its equivalent course content a student may request a personal curriculum in mathematics following A.A.C. R7-2-302.03.

* Math courses shall consist of Algebra I, Geometry, Algebra II, (or its equivalent) and an additional course with significant math content as determined by the Governing Board (Governing Body).

Pursuant to A.R.S. 15-710, a total of one (1) year instruction in state and federal constitutions, American institutions and ideals and in the history of Arizona, including the history of Native Americans in Arizona is required during grades nine (9) through twelve (12).

Pursuant to A.R.S. 15-701.05, if the State Board of Education or the District includes, in the minimum course of study for graduation from high school, a requirement that students receive instruction in a world language, the District will allow a student to satisfy the requirement by demonstrating proficiency in a Native American language in accordance with A.R.S. 15-701.05. This does not require the District to offer a Native American language course. The State Board of Education may establish criteria for evaluating the Native American language proficiency of students.

Pursuant to the prescribed graduation requirements adopted by the State Board of Education, the Governing Board may approve a rigorous computer science course that would fulfill a mathematics course required for graduation from high school. The Governing Board may only approve a rigorous computer science course if the rigorous computer science course includes significant mathematics content and the Governing Board determines the high school where the rigorous computer science course is offered has sufficient capacity, infrastructure and qualified staff, including competent teachers of computer science.

** Three (3) credits of science in preparation for proficiency at the high school level on a state required test.

*** Through the graduating class of 2025, the competency requirements for social studies shall include a requirement that, in order to graduate from high school or obtain a high school equivalency diploma, a student must correctly answer at least sixty (60) of the one hundred (100) questions listed on a test that is identical to the civics portion of the naturalization test used by the United States Citizenship And Immigration Services.

Beginning with the graduating class of 2026, the competency requirements for social studies shall include a requirement that, in order to graduate from high school or obtain a high school equivalency diploma, a student must correctly answer at least seventy (70) of the one hundred (100) questions listed on a test that is identical to the civics portion of the naturalization test used by the United States Citizenship and Immigration Services. The District school shall document on the student's transcript only a pass or fail designation that the student has passed or failed the test.

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A student in grade seven (7) or eight (8) may take the test described in this paragraph, and if the student correctly answers at least seventy (70) of the one hundred (100) questions on the test:

a) The district school or charter school shall document on the student's transcript only a pass or fail designation that the student has passed or failed the test required by this paragraph.

b) The student is not required to take the test required by this paragraph again in high school.

**** The State Board requirement for economics is at least one-half (.5) of a course credit, which shall include financial literacy and personal financial management.

The Governing Board may determine the method and manner in which to administer a test that is identical to the civics portion of the naturalization test used by the United States Citizenship and Immigration Services. A student who does not obtain a passing score on the test that is identical to the civics portion of the naturalization test may retake the test until the student obtains a passing score.

Each school district and charter school shall report to the department of education all of the following aggregate data, organized by grade level, relating to the test that is identical to the civics portion of the naturalization test used by the United States Citizenship and Immigration Services required by subsection A, paragraph 3 of A.R.S. 15-701.01:

1. The median score.

2. The percentage of students who passed by correctly answering the minimum number of questions required to pass the test pursuant to subsection A, paragraph 3 of A.R.S. 15-701.01.

3. The percentage of students who failed by correctly answering fewer than the minimum number of questions required to pass the test pursuant to subsection A, paragraph 3 of A.R.S. 15-701.01.

4. Any other data required by the department relating to the test.

A school district or charter school may not include the personally identifiable information of any student in the data reported to the department of education under subsection L of A.R.S. 15-701.01.

Assessments

If a high school student who is enrolled in a school district or charter school participates in a nationally recognized assessment that is both adopted by the State Board of Education and administered by a person other than the school district or charter school,

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the student or student's parent or guardian may submit the student's official score report for the assessment to the school district or charter school. On receiving an official score report, the school district or charter school shall do all of the following:

1. record the score in the student's file.

2. report the score to the State Board of Education and the Department of Education.

3. If the student or student's parent or guardian submits an official score report to the school district or charter school before the date on which the school administers the tests, allow the student to opt out of participation in the assessment that is administered by the school district or charter school. If a student opts out of an assessment, the school district or charter school shall use the data from the student's official score report for the student's achievement test data. "Nationally recognized" has the same meaning as provided in A.R.S. 15-741.02.

A school district or charter school is not required to allow a student to opt out of the collection of non-test indicator data or other information that is collected about students who participate in the assessment that is administered by the school district or charter school.

Written Assessment

A school district or charter school may administer the statewide assessment in the form of a written test if any of the following applies:

1. a written test is required pursuant to an individualized education program or a section 504 plan.

2. to accommodate special circumstances.

3. for religious purposes.

4. on request by a student's parent or guardian.

Special Education

Listed above, under "Regular Education," are the requirements that must be completed before a student may receive a high school diploma. Completion of graduation requirements for special education students who do not meet the required units of credit shall be determined on a case-by-case basis in accordance with the special education course of study and the individualized education program of the student. Graduation requirements established by the Governing Board may be met by a student as defined in A.R.S. 15-701.01 and A.A.C. R7-2-302.

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Students who receive special education shall not be required to achieve passing scores on the test that is identical to the civics portion of the naturalization test under A.R.S. 15-701.01 in order to graduate from high school unless the student is learning at a level appropriate for the student's grade level in a specific academic area and unless a passing score on the test that is identical to the civics portion of the naturalization test under section 15-701.01 is specifically required in a specific academic area by the student's individualized education program as mutually agreed on by the student's parents and the student's individualized education program team or the student, if the student is at least eighteen (18) years of age.

Competency requirements. Any student who is placed in special education classes, grades nine (9) through twelve (12), is eligible to receive a high school diploma without meeting state competency requirements.

State Seal of Biliteracy. The School District may voluntarily participate in the state seal of biliteracy program by notifying the Superintendent of Public Instruction of such intention. Schools will then identify the students who have met the requirements to be awarded the state seal of biliteracy, which shall be affixed to the diploma and noted on the transcript of each student who has met the requirements.

CPR Instruction and Training. School districts and charter schools shall provide public school students with one (1) or more training sessions in cardiopulmonary resuscitation, through the use of psychomotor skills in an age-appropriate manner, during high school.

Adopted: _____

LEGAL REF.:
A.R.S.
15-203
15-341
15-701.01
15-701.05
15-710
15-741
15-763
A.A.C.
R7-2-302
R7-2-302.03

CROSS REF.:
IGD - Curriculum Adoption
IGE - Curriculum Guides and Course Outlines
IHAMC - Instruction and Training in Cardiopulmonary Resuscitation
IHAMD - Instruction and Training in Suicide Prevention
IIE - Student Schedules and Course Loads
IKA - Grading/Assessment Systems
JFABC - Admission of Transfer Students

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REGULATION

STUDENT ADMISSIONS

Special Programs and Services

Unorganized Territories:

"Unorganized Territory" means a geographic area that is not located within the boundaries of any school district.

A. *Child Find Screening, Special Education Evaluation, Student Enrollment*:

1. The parent of a student who resides in an unorganized territory may request a Child Find screening, a special education evaluation or enrollment of the student in the adjoining school district that is geographically closest to the student 's residence.

2. A school district that receives a request pursuant to this subsection is responsible for all Child Find activities for that student.

3. If a parent of a student who is a student with a disability as defined in A.R.S. 15-761 requests enrollment of the student in a school district, the school district is responsible for providing a free appropriate public education (FAPE) to the student.

B. *Early Intervention Services*:

1. Each program that provides early intervention services to student's who reside in unorganized territories shall initiate the process for transitioning the student from Part C to Part B of the Individuals with Disabilities Education Act (IDEA) by notifying the Department of Education and referring the student to the adjoining school district that is geographically closest to the student's residence for a special education evaluation and transition at least ninety days before the student's third (3rd) birthday.

2. If a program determines that a student who resides in an unorganized territory is eligible for early intervention services pursuant to Part C of IDEA more than forty-five (45) days but fewer than ninety (90) days before the student's third (3rd) birthday, the program shall initiate the process for transitioning the student from Part C to Part B of IDEA as soon as possible, consistent with federal law.

C. *Special Education Evaluation*:

1. If the adjoining school district that is geographically closest to the residence of a student conducts a special education evaluation of the student and determines that the student is eligible for special education and related

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services under Part B of IDEA, the student's parent(s) may request enrollment of the student in the school district at any time and the school district shall inform the student's parent(s) that the student's parent(s) may request enrollment of the student.

2. On receipt of a request for enrollment of a student residing in an unorganized territory, the school district shall prepare a Certificate of Educational Convenience application for the student as prescribed by A.R.S. 15-825 and offer a free appropriate public education to the student.

D. *Private School or Homeschool.* If a student resides in an unorganized territory and either is parentally placed in a private school or attends a homeschool, the following apply:

1. The student retains the rights established under 20 U.S.C. section 1412, including the rights to be identified, located and evaluated for eligibility under Part B of IDEA.

2. If the student is parentally placed in a nonprofit private school or attends a homeschool, the student retains the right to equitable services under proportionate share funding pursuant to 20 U.S.C. section 1412.

3. The school district that is responsible for conducting the activities described in paragraph D.1 of this regulation and for providing the services described in paragraph D.2 of this regulation for the student is:

a. If the student is parentally placed in a nonprofit private school that is located within the boundaries of a school district, the school district in which the private school is located.

b. If the student is parentally placed in a nonprofit private school that is located in an unorganized territory, the adjoining school district that is geographically closest to the private school.

c. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit, the adjoining school district that is geographically closest to the student's residence.

Placement by Court or State:

"State Placing Agency" means the department of juvenile corrections, the department of economic security, the department of child safety, the Arizona health care cost containment system or the administrative office of the court.

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E. If a student is placed by a state placing agency or a court of competent jurisdiction in a residential placement described in section 15-823(C), and either is parentally placed in a private school or attends a homeschool, the following apply:

1. The student retains the rights established under 20 U.S.C. section 1412, including the rights to be identified, located and evaluated for eligibility under Part B of IDEA.

2. If the student is parentally placed in a nonprofit private school or attends a homeschool, the student retains the right to equitable services under proportionate share funding pursuant to 20 U.S.C. section 1412.

3. The school district that is responsible for conducting the activities described in paragraph E.1 above and for providing the services described in paragraph E. 2 above for the student is:

a. If the student is parentally placed in a nonprofit private school that is located within the boundaries of a school district, the school district in which the private school is located.

b. If the student is parentally placed in a nonprofit private school that is located in an unorganized territory, the adjoining school district that is geographically closest to the private school.

c. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit and the residential placement is located within the boundaries of a school district, the school district in which the residential placement is located.

d. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit and the residential placement is located in an unorganized territory, the adjoining school district that is geographically closest to the residential placement.

Parent Request for Identification of Closest Adjoining District

On request from a student or a student's parent, a county school superintendent shall identify the adjoining school district that is geographically closest to the student's residence or residential placement.

Definitions

For the purposes of this section:

A. "Child find activities" means state obligations pursuant to 20 U.S.C. section 1412(a)(3), the federal regulations issued pursuant to IDEA and the rules adopted by the State Board of Education relating to the identification and referral of children with disabilities by public schools.

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B. "Free appropriate public education" has the same meaning prescribed in 20 U.S.C. section 1401.

C. "Homeschool" has the same meaning prescribed in A.R.S. 15-802.

D. "Unorganized territory" has the same meaning prescribed in section A.R.S. 15-825.

E. "Related services" has the same meaning prescribed in 20 U.S.C. section 1401.

F. "Special education" has the same meaning prescribed in 20 U.S.C. section 1401.

G. "Special education evaluation" means an evaluation conducted pursuant to A.R.S. 15-766 and rules adopted by the State Board of Education.

H. "State placing agency" has the same meaning prescribed in A.R.S. 15-1181.

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REGULATION

ADMISSION OF RESIDENT STUDENTS

Special Programs and Services

Unorganized Territories:

"Unorganized Territory" means a geographic area that is not located within the boundaries of any school district.

A. *Child Find Screening, Special Education Evaluation, Student Enrollment*:

1. The parent of a student who resides in an unorganized territory may request a Child Find screening, a special education evaluation or enrollment of the student in the adjoining school district that is geographically closest to the student 's residence.

2. A school district that receives a request pursuant to this subsection is responsible for all Child Find activities for that student.

3. If a parent of a student who is a student with a disability as defined in A.R.S. 15-761 requests enrollment of the student in a school district, the school district is responsible for providing a free appropriate public education (FAPE) to the student.

B. *Early Intervention Services*:

1. Each program that provides early intervention services to student's who reside in unorganized territories shall initiate the process for transitioning the student from Part C to Part B of the Individuals with Disabilities Education Act (IDEA) by notifying the Department of Education and referring the student to the adjoining school district that is geographically closest to the student's residence for a special education evaluation and transition at least ninety days before the student's third (3rd) birthday.

2. If a program determines that a student who resides in an unorganized territory is eligible for early intervention services pursuant to Part C of IDEA more than forty-five (45) days but fewer than ninety (90) days before the student's third (3rd) birthday, the program shall initiate the process for transitioning the student from Part C to Part B of IDEA as soon as possible, consistent with federal law.

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C. *Special Education Evaluation*:

1. If the adjoining school district that is geographically closest to the residence of a student conducts a special education evaluation of the student and determines that the student is eligible for special education and related services under Part B of IDEA, the student's parent(s) may request enrollment of the student in the school district at any time and the school district shall inform the student's parent(s) that the student's parent(s) may request enrollment of the student.

2. On receipt of a request for enrollment of a student residing in an unorganized territory, the school district shall prepare a Certificate of Educational Convenience application for the student as prescribed by A.R.S. 15-825 and offer a free appropriate public education to the student.

D. *Private School or Homeschool*. If a student resides in an unorganized territory and either is parentally placed in a private school or attends a homeschool, the following apply:

1. The student retains the rights established under 20 U.S.C. section 1412, including the rights to be identified, located and evaluated for eligibility under Part B of IDEA.

2. If the student is parentally placed in a nonprofit private school or attends a homeschool, the student retains the right to equitable services under proportionate share funding pursuant to 20 U.S.C. section 1412.

3. The school district that is responsible for conducting the activities described in paragraph D.1 of this regulation and for providing the services described in paragraph D.2 of this regulation for the student is:

a. If the student is parentally placed in a nonprofit private school that is located within the boundaries of a school district, the school district in which the private school is located.

b. If the student is parentally placed in a nonprofit private school that is located in an unorganized territory, the adjoining school district that is geographically closest to the private school.

c. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit, the adjoining school district that is geographically closest to the student's residence.

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Placement by Court or State:

"State Placing Agency" means the department of juvenile corrections, the department of economic security, the department of child safety, the Arizona health care cost containment system or the administrative office of the court.

E. If a student is placed by a state placing agency or a court of competent jurisdiction in a residential placement described in section 15-823(C), and either is parentally placed in a private school or attends a homeschool, the following apply:

1. The student retains the rights established under 20 U.S.C. section 1412, including the rights to be identified, located and evaluated for eligibility under Part B of IDEA.

2. If the student is parentally placed in a nonprofit private school or attends a homeschool, the student retains the right to equitable services under proportionate share funding pursuant to 20 U.S.C. section 1412.

3. The school district that is responsible for conducting the activities described in paragraph E.1 above and for providing the services described in paragraph E. 2 above for the student is:

a. If the student is parentally placed in a nonprofit private school that is located within the boundaries of a school district, the school district in which the private school is located.

b. If the student is parentally placed in a nonprofit private school that is located in an unorganized territory, the adjoining school district that is geographically closest to the private school.

c. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit and the residential placement is located within the boundaries of a school district, the school district in which the residential placement is located.

d. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit and the residential placement is located in an unorganized territory, the adjoining school district that is geographically closest to the residential placement.

Parent Request for Identification of Closest Adjoining District

On request from a student or a student's parent, a county school superintendent shall identify the adjoining school district that is geographically closest to the student's residence or residential placement.

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Definitions

For the purposes of this section:

A. "Child find activities" means state obligations pursuant to 20 U.S.C. section 1412(a)(3), the federal regulations issued pursuant to IDEA and the rules adopted by the State Board of Education relating to the identification and referral of children with disabilities by public schools.

B. "Free appropriate public education" has the same meaning prescribed in 20 U.S.C. section 1401.

C. "Homeschool" has the same meaning prescribed in A.R.S. 15-802.

D. "Unorganized territory" has the same meaning prescribed in section A.R.S. 15-825.

E. "Related services" has the same meaning prescribed in 20 U.S.C. section 1401.

F. "Special education" has the same meaning prescribed in 20 U.S.C. section 1401.

G. "Special education evaluation" means an evaluation conducted pursuant to A.R.S. 15-766 and rules adopted by the State Board of Education.

H. "State placing agency" has the same meaning prescribed in A.R.S. 15-1181.

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REGULATION

TUITION / ADMISSION OF NONRESIDENT STUDENTS

Special Programs and Services

Unorganized Territories:

"Unorganized Territory" means a geographic area that is not located within the boundaries of any school district.

A. *Child Find Screening, Special Education Evaluation, Student Enrollment*:

1. The parent of a student who resides in an unorganized territory may request a Child Find screening, a special education evaluation or enrollment of the student in the adjoining school district that is geographically closest to the student 's residence.

2. A school district that receives a request pursuant to this subsection is responsible for all Child Find activities for that student.

3. If a parent of a student who is a student with a disability as defined in A.R.S. 15-761 requests enrollment of the student in a school district, the school district is responsible for providing a free appropriate public education (FAPE) to the student.

B. *Early Intervention Services*:

1. Each program that provides early intervention services to student's who reside in unorganized territories shall initiate the process for transitioning the student from Part C to Part B of the Individuals with Disabilities Education Act (IDEA) by notifying the Department of Education and referring the student to the adjoining school district that is geographically closest to the student's residence for a special education evaluation and transition at least ninety days before the student's third (3rd) birthday.

2. If a program determines that a student who resides in an unorganized territory is eligible for early intervention services pursuant to Part C of IDEA more than forty-five (45) days but fewer than ninety (90) days before the student's third (3rd) birthday, the program shall initiate the process for transitioning the student from Part C to Part B of IDEA as soon as possible, consistent with federal law.

C. *Special Education Evaluation*:

1. If the adjoining school district that is geographically closest to the residence of a student conducts a special education evaluation of the student and

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determines that the student is eligible for special education and related services under Part B of IDEA, the student's parent(s) may request enrollment of the student in the school district at any time and the school district shall inform the student's parent(s) that the student's parent(s) may request enrollment of the student.

2. On receipt of a request for enrollment of a student residing in an unorganized territory, the school district shall prepare a Certificate of Educational Convenience application for the student as prescribed by A.R.S. 15-825 and offer a free appropriate public education to the student.

D. *Private School or Homeschool.* If a student resides in an unorganized territory and either is parentally placed in a private school or attends a homeschool, the following apply:

1. The student retains the rights established under 20 U.S.C. section 1412, including the rights to be identified, located and evaluated for eligibility under Part B of IDEA.

2. If the student is parentally placed in a nonprofit private school or attends a homeschool, the student retains the right to equitable services under proportionate share funding pursuant to 20 U.S.C. section 1412.

3. The school district that is responsible for conducting the activities described in paragraph D.1 of this regulation and for providing the services described in paragraph D.2 of this regulation for the student is:

a. If the student is parentally placed in a nonprofit private school that is located within the boundaries of a school district, the school district in which the private school is located.

b. If the student is parentally placed in a nonprofit private school that is located in an unorganized territory, the adjoining school district that is geographically closest to the private school.

c. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit, the adjoining school district that is geographically closest to the student's residence.

Placement by Court or State:

"State Placing Agency" means the department of juvenile corrections, the department of economic security, the department of child safety, the Arizona health care cost containment system or the administrative office of the court.

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E. If a student is placed by a state placing agency or a court of competent jurisdiction in a residential placement described in section 15-823(C), and either is parentally placed in a private school or attends a homeschool, the following apply:

1. The student retains the rights established under 20 U.S.C. section 1412, including the rights to be identified, located and evaluated for eligibility under Part B of IDEA.

2. If the student is parentally placed in a nonprofit private school or attends a homeschool, the student retains the right to equitable services under proportionate share funding pursuant to 20 U.S.C. section 1412.

3. The school district that is responsible for conducting the activities described in paragraph E.1 above and for providing the services described in paragraph E. 2 above for the student is:

a. If the student is parentally placed in a nonprofit private school that is located within the boundaries of a school district, the school district in which the private school is located.

b. If the student is parentally placed in a nonprofit private school that is located in an unorganized territory, the adjoining school district that is geographically closest to the private school.

c. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit and the residential placement is located within the boundaries of a school district, the school district in which the residential placement is located.

d. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit and the residential placement is located in an unorganized territory, the adjoining school district that is geographically closest to the residential placement.

Parent Request for Identification of Closest Adjoining District

On request from a student or a student's parent, a county school superintendent shall identify the adjoining school district that is geographically closest to the student's residence or residential placement.

Definitions

For the purposes of this section:

A. "Child find activities" means state obligations pursuant to 20 U.S.C. section 1412(a)(3), the federal regulations issued pursuant to IDEA and the rules adopted by the State Board of Education relating to the identification and referral of children with disabilities by public schools.

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B. "Free appropriate public education" has the same meaning prescribed in 20 U.S.C. section 1401.

C. "Homeschool" has the same meaning prescribed in A.R.S. 15-802.

D. "Unorganized territory" has the same meaning prescribed in section A.R.S. 15-825.

E. "Related services" has the same meaning prescribed in 20 U.S.C. section 1401.

F. "Special education" has the same meaning prescribed in 20 U.S.C. section 1401.

G. "Special education evaluation" means an evaluation conducted pursuant to A.R.S. 15-766 and rules adopted by the State Board of Education.

H. "State placing agency" has the same meaning prescribed in A.R.S. 15-1181.

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REGULATION

ADMISSION OF TRANSFER STUDENTS

Special Programs and Services

Unorganized Territories:

"Unorganized Territory" means a geographic area that is not located within the boundaries of any school district.

A. *Child Find Screening, Special Education Evaluation, Student Enrollment*:

1. The parent of a student who resides in an unorganized territory may request a Child Find screening, a special education evaluation or enrollment of the student in the adjoining school district that is geographically closest to the student 's residence.

2. A school district that receives a request pursuant to this subsection is responsible for all Child Find activities for that student.

3. If a parent of a student who is a student with a disability as defined in A.R.S. 15-761 requests enrollment of the student in a school district, the school district is responsible for providing a free appropriate public education (FAPE) to the student.

B. *Early Intervention Services*:

1. Each program that provides early intervention services to student's who reside in unorganized territories shall initiate the process for transitioning the student from Part C to Part B of the Individuals with Disabilities Education Act (IDEA) by notifying the Department of Education and referring the student to the adjoining school district that is geographically closest to the student's residence for a special education evaluation and transition at least ninety days before the student's third (3rd) birthday.

2. If a program determines that a student who resides in an unorganized territory is eligible for early intervention services pursuant to Part C of IDEA more than forty-five (45) days but fewer than ninety (90) days before the student's third (3rd) birthday, the program shall initiate the process for transitioning the student from Part C to Part B of IDEA as soon as possible, consistent with federal law.

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C. *Special Education Evaluation*:

1. If the adjoining school district that is geographically closest to the residence of a student conducts a special education evaluation of the student and determines that the student is eligible for special education and related services under Part B of IDEA, the student's parent(s) may request enrollment of the student in the school district at any time and the school district shall inform the student's parent(s) that the student's parent(s) may request enrollment of the student.

2. On receipt of a request for enrollment of a student residing in an unorganized territory, the school district shall prepare a Certificate of Educational Convenience application for the student as prescribed by A.R.S. 15-825 and offer a free appropriate public education to the student.

D. *Private School or Homeschool*. If a student resides in an unorganized territory and either is parentally placed in a private school or attends a homeschool, the following apply:

1. The student retains the rights established under 20 U.S.C. section 1412, including the rights to be identified, located and evaluated for eligibility under Part B of IDEA.

2. If the student is parentally placed in a nonprofit private school or attends a homeschool, the student retains the right to equitable services under proportionate share funding pursuant to 20 U.S.C. section 1412.

3. The school district that is responsible for conducting the activities described in paragraph D.1 of this regulation and for providing the services described in paragraph D.2 of this regulation for the student is:

a. If the student is parentally placed in a nonprofit private school that is located within the boundaries of a school district, the school district in which the private school is located.

b. If the student is parentally placed in a nonprofit private school that is located in an unorganized territory, the adjoining school district that is geographically closest to the private school.

c. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit, the adjoining school district that is geographically closest to the student's residence.

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Placement by Court or State:

"State Placing Agency" means the department of juvenile corrections, the department of economic security, the department of child safety, the Arizona health care cost containment system or the administrative office of the court.

E. If a student is placed by a state placing agency or a court of competent jurisdiction in a residential placement described in section 15-823(C), and either is parentally placed in a private school or attends a homeschool, the following apply:

1. The student retains the rights established under 20 U.S.C. section 1412, including the rights to be identified, located and evaluated for eligibility under Part B of IDEA.

2. If the student is parentally placed in a nonprofit private school or attends a homeschool, the student retains the right to equitable services under proportionate share funding pursuant to 20 U.S.C. section 1412.

3. The school district that is responsible for conducting the activities described in paragraph E.1 above and for providing the services described in paragraph E. 2 above for the student is:

a. If the student is parentally placed in a nonprofit private school that is located within the boundaries of a school district, the school district in which the private school is located.

b. If the student is parentally placed in a nonprofit private school that is located in an unorganized territory, the adjoining school district that is geographically closest to the private school.

c. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit and the residential placement is located within the boundaries of a school district, the school district in which the residential placement is located.

d. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit and the residential placement is located in an unorganized territory, the adjoining school district that is geographically closest to the residential placement.

Parent Request for Identification of Closest Adjoining District

On request from a student or a student's parent, a county school superintendent shall identify the adjoining school district that is geographically closest to the student's residence or residential placement.

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Definitions

For the purposes of this section:

A. "Child find activities" means state obligations pursuant to 20 U.S.C. section 1412(a)(3), the federal regulations issued pursuant to IDEA and the rules adopted by the State Board of Education relating to the identification and referral of children with disabilities by public schools.

B. "Free appropriate public education" has the same meaning prescribed in 20 U.S.C. section 1401.

C. "Homeschool" has the same meaning prescribed in A.R.S. 15-802.

D. "Unorganized territory" has the same meaning prescribed in section A.R.S. 15-825.

E. "Related services" has the same meaning prescribed in 20 U.S.C. section 1401.

F. "Special education" has the same meaning prescribed in 20 U.S.C. section 1401.

G. "Special education evaluation" means an evaluation conducted pursuant to A.R.S. 15-766 and rules adopted by the State Board of Education.

H. "State placing agency" has the same meaning prescribed in A.R.S. 15-1181.

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REGULATION

ADMISSION OF HOMELESS STUDENTS

Special Programs and Services

Unorganized Territories:

"Unorganized Territory" means a geographic area that is not located within the boundaries of any school district.

A. *Child Find Screening, Special Education Evaluation, Student Enrollment*:

1. The parent of a student who resides in an unorganized territory may request a Child Find screening, a special education evaluation or enrollment of the student in the adjoining school district that is geographically closest to the student 's residence.

2. A school district that receives a request pursuant to this subsection is responsible for all Child Find activities for that student.

3. If a parent of a student who is a student with a disability as defined in A.R.S. 15-761 requests enrollment of the student in a school district, the school district is responsible for providing a free appropriate public education (FAPE) to the student.

B. *Early Intervention Services*:

1. Each program that provides early intervention services to student's who reside in unorganized territories shall initiate the process for transitioning the student from Part C to Part B of the Individuals with Disabilities Education Act (IDEA) by notifying the Department of Education and referring the student to the adjoining school district that is geographically closest to the student's residence for a special education evaluation and transition at least ninety days before the student's third (3rd) birthday.

2. If a program determines that a student who resides in an unorganized territory is eligible for early intervention services pursuant to Part C of IDEA more than forty-five (45) days but fewer than ninety (90) days before the student's third (3rd) birthday, the program shall initiate the process for transitioning the student from Part C to Part B of IDEA as soon as possible, consistent with federal law.

C. *Special Education Evaluation*:

1. If the adjoining school district that is geographically closest to the residence of a student conducts a special education evaluation of the student and

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determines that the student is eligible for special education and related services under Part B of IDEA, the student's parent(s) may request enrollment of the student in the school district at any time and the school district shall inform the student's parent(s) that the student's parent(s) may request enrollment of the student.

2. On receipt of a request for enrollment of a student residing in an unorganized territory, the school district shall prepare a Certificate of Educational Convenience application for the student as prescribed by A.R.S. 15-825 and offer a free appropriate public education to the student.

D. *Private School or Homeschool.* If a student resides in an unorganized territory and either is parentally placed in a private school or attends a homeschool, the following apply:

1. The student retains the rights established under 20 U.S.C. section 1412, including the rights to be identified, located and evaluated for eligibility under Part B of IDEA.

2. If the student is parentally placed in a nonprofit private school or attends a homeschool, the student retains the right to equitable services under proportionate share funding pursuant to 20 U.S.C. section 1412.

3. The school district that is responsible for conducting the activities described in paragraph D.1 of this regulation and for providing the services described in paragraph D.2 of this regulation for the student is:

a. If the student is parentally placed in a nonprofit private school that is located within the boundaries of a school district, the school district in which the private school is located.

b. If the student is parentally placed in a nonprofit private school that is located in an unorganized territory, the adjoining school district that is geographically closest to the private school.

c. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit, the adjoining school district that is geographically closest to the student's residence.

Placement by Court or State:

"State Placing Agency" means the department of juvenile corrections, the department of economic security, the department of child safety, the Arizona health care cost containment system or the administrative office of the court.

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E. If a student is placed by a state placing agency or a court of competent jurisdiction in a residential placement described in section 15-823(C), and either is parentally placed in a private school or attends a homeschool, the following apply:

1. The student retains the rights established under 20 U.S.C. section 1412, including the rights to be identified, located and evaluated for eligibility under Part B of IDEA.

2. If the student is parentally placed in a nonprofit private school or attends a homeschool, the student retains the right to equitable services under proportionate share funding pursuant to 20 U.S.C. section 1412.

3. The school district that is responsible for conducting the activities described in paragraph E.1 above and for providing the services described in paragraph E. 2 above for the student is:

a. If the student is parentally placed in a nonprofit private school that is located within the boundaries of a school district, the school district in which the private school is located.

b. If the student is parentally placed in a nonprofit private school that is located in an unorganized territory, the adjoining school district that is geographically closest to the private school.

c. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit and the residential placement is located within the boundaries of a school district, the school district in which the residential placement is located.

d. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit and the residential placement is located in an unorganized territory, the adjoining school district that is geographically closest to the residential placement.

Parent Request for Identification of Closest Adjoining District

On request from a student or a student's parent, a county school superintendent shall identify the adjoining school district that is geographically closest to the student's residence or residential placement.

Definitions

For the purposes of this section:

A. "Child find activities" means state obligations pursuant to 20 U.S.C. section 1412(a)(3), the federal regulations issued pursuant to IDEA and the rules adopted by the State Board of Education relating to the identification and referral of children with disabilities by public schools.

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B. "Free appropriate public education" has the same meaning prescribed in 20 U.S.C. section 1401.

C. "Homeschool" has the same meaning prescribed in A.R.S. 15-802.

D. "Unorganized territory" has the same meaning prescribed in section A.R.S. 15-825.

E. "Related services" has the same meaning prescribed in 20 U.S.C. section 1401.

F. "Special education" has the same meaning prescribed in 20 U.S.C. section 1401.

G. "Special education evaluation" means an evaluation conducted pursuant to A.R.S. 15-766 and rules adopted by the State Board of Education.

H. "State placing agency" has the same meaning prescribed in A.R.S. 15-1181.

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REGULATION

ADMISSION OF STUDENTS IN FOSTER CARE

Special Programs and Services

Unorganized Territories:

"Unorganized Territory" means a geographic area that is not located within the boundaries of any school district.

A. *Child Find Screening, Special Education Evaluation, Student Enrollment*:

1. The parent of a student who resides in an unorganized territory may request a Child Find screening, a special education evaluation or enrollment of the student in the adjoining school district that is geographically closest to the student 's residence.

2. A school district that receives a request pursuant to this subsection is responsible for all Child Find activities for that student.

3. If a parent of a student who is a student with a disability as defined in A.R.S. 15-761 requests enrollment of the student in a school district, the school district is responsible for providing a free appropriate public education (FAPE) to the student.

B. *Early Intervention Services*:

1. Each program that provides early intervention services to student's who reside in unorganized territories shall initiate the process for transitioning the student from Part C to Part B of the Individuals with Disabilities Education Act (IDEA) by notifying the Department of Education and referring the student to the adjoining school district that is geographically closest to the student's residence for a special education evaluation and transition at least ninety days before the student's third (3rd) birthday.

2. If a program determines that a student who resides in an unorganized territory is eligible for early intervention services pursuant to Part C of IDEA more than forty-five (45) days but fewer than ninety (90) days before the student's third (3rd) birthday, the program shall initiate the process for transitioning the student from Part C to Part B of IDEA as soon as possible, consistent with federal law.

C. *Special Education Evaluation*:

1. If the adjoining school district that is geographically closest to the residence of a student conducts a special education evaluation of the student and

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determines that the student is eligible for special education and related services under Part B of IDEA, the student's parent(s) may request enrollment of the student in the school district at any time and the school district shall inform the student's parent(s) that the student's parent(s) may request enrollment of the student.

2. On receipt of a request for enrollment of a student residing in an unorganized territory, the school district shall prepare a Certificate of Educational Convenience application for the student as prescribed by A.R.S. 15-825 and offer a free appropriate public education to the student.

D. *Private School or Homeschool.* If a student resides in an unorganized territory and either is parentally placed in a private school or attends a homeschool, the following apply:

1. The student retains the rights established under 20 U.S.C. section 1412, including the rights to be identified, located and evaluated for eligibility under Part B of IDEA.

2. If the student is parentally placed in a nonprofit private school or attends a homeschool, the student retains the right to equitable services under proportionate share funding pursuant to 20 U.S.C. section 1412.

3. The school district that is responsible for conducting the activities described in paragraph D.1 of this regulation and for providing the services described in paragraph D.2 of this regulation for the student is:

a. If the student is parentally placed in a nonprofit private school that is located within the boundaries of a school district, the school district in which the private school is located.

b. If the student is parentally placed in a nonprofit private school that is located in an unorganized territory, the adjoining school district that is geographically closest to the private school.

c. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit, the adjoining school district that is geographically closest to the student's residence.

Placement by Court or State:

"State Placing Agency" means the department of juvenile corrections, the department of economic security, the department of child safety, the Arizona health care cost containment system or the administrative office of the court.

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E. If a student is placed by a state placing agency or a court of competent jurisdiction in a residential placement described in section 15-823(C), and either is parentally placed in a private school or attends a homeschool, the following apply:

1. The student retains the rights established under 20 U.S.C. section 1412, including the rights to be identified, located and evaluated for eligibility under Part B of IDEA.

2. If the student is parentally placed in a nonprofit private school or attends a homeschool, the student retains the right to equitable services under proportionate share funding pursuant to 20 U.S.C. section 1412.

3. The school district that is responsible for conducting the activities described in paragraph E.1 above and for providing the services described in paragraph E. 2 above for the student is:

a. If the student is parentally placed in a nonprofit private school that is located within the boundaries of a school district, the school district in which the private school is located.

b. If the student is parentally placed in a nonprofit private school that is located in an unorganized territory, the adjoining school district that is geographically closest to the private school.

c. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit and the residential placement is located within the boundaries of a school district, the school district in which the residential placement is located.

d. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit and the residential placement is located in an unorganized territory, the adjoining school district that is geographically closest to the residential placement.

Parent Request for Identification of Closest Adjoining District

On request from a student or a student's parent, a county school superintendent shall identify the adjoining school district that is geographically closest to the student's residence or residential placement.

Definitions

For the purposes of this section:

A. "Child find activities" means state obligations pursuant to 20 U.S.C. section 1412(a)(3), the federal regulations issued pursuant to IDEA and the rules adopted by the State Board of Education relating to the identification and referral of children with disabilities by public schools.

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B. "Free appropriate public education" has the same meaning prescribed in 20 U.S.C. section 1401.

C. "Homeschool" has the same meaning prescribed in A.R.S. 15-802.

D. "Unorganized territory" has the same meaning prescribed in section A.R.S. 15-825.

E. "Related services" has the same meaning prescribed in 20 U.S.C. section 1401.

F. "Special education" has the same meaning prescribed in 20 U.S.C. section 1401.

G. "Special education evaluation" means an evaluation conducted pursuant to A.R.S. 15-766 and rules adopted by the State Board of Education.

H. "State placing agency" has the same meaning prescribed in A.R.S. 15-1181.

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REGULATION

OPEN ENROLLMENT

Special Programs and Services

Unorganized Territories:

"Unorganized Territory" means a geographic area that is not located within the boundaries of any school district.

A. *Child Find Screening, Special Education Evaluation, Student Enrollment*:

1. The parent of a student who resides in an unorganized territory may request a Child Find screening, a special education evaluation or enrollment of the student in the adjoining school district that is geographically closest to the student 's residence.

2. A school district that receives a request pursuant to this subsection is responsible for all Child Find activities for that student.

3. If a parent of a student who is a student with a disability as defined in A.R.S. 15-761 requests enrollment of the student in a school district, the school district is responsible for providing a free appropriate public education (FAPE) to the student.

B. *Early Intervention Services*:

1. Each program that provides early intervention services to student's who reside in unorganized territories shall initiate the process for transitioning the student from Part C to Part B of the Individuals with Disabilities Education Act (IDEA) by notifying the Department of Education and referring the student to the adjoining school district that is geographically closest to the student's residence for a special education evaluation and transition at least ninety days before the student's third (3rd) birthday.

2. If a program determines that a student who resides in an unorganized territory is eligible for early intervention services pursuant to Part C of IDEA more than forty-five (45) days but fewer than ninety (90) days before the student's third (3rd) birthday, the program shall initiate the process for transitioning the student from Part C to Part B of IDEA as soon as possible, consistent with federal law.

C. *Special Education Evaluation*:

1. If the adjoining school district that is geographically closest to the residence of a student conducts a special education evaluation of the student and

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determines that the student is eligible for special education and related services under Part B of IDEA, the student's parent(s) may request enrollment of the student in the school district at any time and the school district shall inform the student's parent(s) that the student's parent(s) may request enrollment of the student.

2. On receipt of a request for enrollment of a student residing in an unorganized territory, the school district shall prepare a Certificate of Educational Convenience application for the student as prescribed by A.R.S. 15-825 and offer a free appropriate public education to the student.

D. *Private School or Homeschool.* If a student resides in an unorganized territory and either is parentally placed in a private school or attends a homeschool, the following apply:

1. The student retains the rights established under 20 U.S.C. section 1412, including the rights to be identified, located and evaluated for eligibility under Part B of IDEA.

2. If the student is parentally placed in a nonprofit private school or attends a homeschool, the student retains the right to equitable services under proportionate share funding pursuant to 20 U.S.C. section 1412.

3. The school district that is responsible for conducting the activities described in paragraph D.1 of this regulation and for providing the services described in paragraph D.2 of this regulation for the student is:

a. If the student is parentally placed in a nonprofit private school that is located within the boundaries of a school district, the school district in which the private school is located.

b. If the student is parentally placed in a nonprofit private school that is located in an unorganized territory, the adjoining school district that is geographically closest to the private school.

c. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit, the adjoining school district that is geographically closest to the student's residence.

Placement by Court or State:

"State Placing Agency" means the department of juvenile corrections, the department of economic security, the department of child safety, the Arizona health care cost containment system or the administrative office of the court.

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E. If a student is placed by a state placing agency or a court of competent jurisdiction in a residential placement described in section 15-823(C), and either is parentally placed in a private school or attends a homeschool, the following apply:

1. The student retains the rights established under 20 U.S.C. section 1412, including the rights to be identified, located and evaluated for eligibility under Part B of IDEA.

2. If the student is parentally placed in a nonprofit private school or attends a homeschool, the student retains the right to equitable services under proportionate share funding pursuant to 20 U.S.C. section 1412.

3. The school district that is responsible for conducting the activities described in paragraph E.1 above and for providing the services described in paragraph E. 2 above for the student is:

a. If the student is parentally placed in a nonprofit private school that is located within the boundaries of a school district, the school district in which the private school is located.

b. If the student is parentally placed in a nonprofit private school that is located in an unorganized territory, the adjoining school district that is geographically closest to the private school.

c. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit and the residential placement is located within the boundaries of a school district, the school district in which the residential placement is located.

d. If the student attends a homeschool or is parentally placed in a private school that is not a nonprofit and the residential placement is located in an unorganized territory, the adjoining school district that is geographically closest to the residential placement.

Parent Request for Identification of Closest Adjoining District

On request from a student or a student's parent, a county school superintendent shall identify the adjoining school district that is geographically closest to the student's residence or residential placement.

Definitions

For the purposes of this section:

A. "Child find activities" means state obligations pursuant to 20 U.S.C. section 1412(a)(3), the federal regulations issued pursuant to IDEA and the rules adopted by the State Board of Education relating to the identification and referral of children with disabilities by public schools.

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B. "Free appropriate public education" has the same meaning prescribed in 20 U.S.C. section 1401.

C. "Homeschool" has the same meaning prescribed in A.R.S. 15-802.

D. "Unorganized territory" has the same meaning prescribed in section A.R.S. 15-825.

E. "Related services" has the same meaning prescribed in 20 U.S.C. section 1401.

F. "Special education" has the same meaning prescribed in 20 U.S.C. section 1401.

G. "Special education evaluation" means an evaluation conducted pursuant to A.R.S. 15-766 and rules adopted by the State Board of Education.

H. "State placing agency" has the same meaning prescribed in A.R.S. 15-1181.

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LIMITED OPEN / CLOSED FORUM

Student meetings may be held in the school(s) of the District that offer instruction in grades seven (7) and eight (8) or above under a "limited open forum" if requested by a pupil in grade seven (7) or above. Furthermore, insofar as the District has a procedure defined as a "limited open forum" under the provisions of Title VIII, the Equal Access Act, Section 801 et seq., the District school(s) shall offer to students a fair opportunity to conduct meetings using school facilities whereupon:

A. Such meetings are voluntary and student initiated.

B. There is no sponsorship of such meetings by the District, District employees or governmental entities, or employees of governmental entities.

C. District employees present at religious meetings will be present only in a nonparticipatory capacity.

D. Such meetings shall not materially and substantially interfere with the orderly conduct of the educational activities of the District.

E. Nonschool persons shall not be permitted to direct, conduct, control, or regularly attend such student group meetings.

Patriotic Youth Group

A public school may not deny a patriotic youth group equal access or a fair opportunity to meet in a designated open forum or limited public forum, or otherwise discriminate against the group, including on the basis of its membership or leadership requirements or its oath of allegiance to God and country. For purposes of this policy, the term *patriotic youth group* has the meaning prescribed in A.R.S. 15-120.08.

Any patriotic youth group representative who seeks to address students must, during the first two (2) weeks of the school year, submit a verbal or written request to the principal. The principal may provide a verbal or written approval with an assigned date and time for the presentation. Pursuant to A.R.S. 15-120.08(A) the presentation will be scheduled during the first quarter of the academic school year and may be scheduled during regular school hours. Subject to the conditions provided in 15-120.08(B), the principal may accept materials from the patriotic youth group for distribution to students.

Neither the District, any employee or agent of the District, nor of any state or federal governmental entity shall be permitted to:

A. Influence the form or content of any prayer or other religious activity connected

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with student meetings.

B. Require any person to participate in prayer or other religious activity.

C. Expend public funds beyond the incidental cost of providing the space for such student-initiated meetings.

D. Compel any employee of the District to attend a school meeting that is contrary to the beliefs of the employee.

E. Sanction meetings that are otherwise unlawful.

F. Limit the rights of groups of students to avail themselves under the provisions of this policy to a specified numerical size.

G. Abridge either Arizona or U.S. constitutional rights of any employee, official, or student of the District.

Nothing in this policy shall be construed to limit the authority of the school or its agents or employees to maintain order and discipline on school premises, to protect the well-being of students and employees, and to assure that attendance of students at such meetings is voluntary.

Adopted: _____

LEGAL REF.:
A.R.S.
15-120.08
15-720
20 U.S.C. 4071 et seq., Equal Access Act, (Section 801)
20 U.S.C. 7905

CROSS REF.:
KF - Community Use of School Facilities

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REGULATION

STUDENT RECORDS

This regulation is designed to meet the provisions of the Family Educational Rights and Privacy Act (FERPA) and the Individuals with Disabilities in Education Act (IDEA). All personnel in the District are expected to fulfill the requirements of policy and the following procedures in order to protect the confidentiality of personally identifiable information at collection, storage, disclosure, and destruction stages [34 C.F.R. 300.612].

The Superintendent has the responsibility for ensuring the confidentiality of any personally identifiable information [34 C.F.R. 300.612].

All rights and protections given parents under the FERPA and this regulation transfer to the student upon reaching age eighteen (18) except where the student continues as a dependent under specified circumstances, or enrolling in a postsecondary school. The student then becomes an "eligible student" [34 C.F.R. 99.5 and 300.625].

Definitions

For the purpose of this regulation, the District has used the following definitions of terms:

A. *Student* - Any person who attends or has attended a program of instruction sponsored by the District and for whom the District maintains education records.

B. *Eligible student* - A student who is at least eighteen (18) years of age or is emancipated.

C. *Parent* - Either the natural parent of a student, unless the parent's rights under the FERPA have been removed by a court order, statute, or other legal document, or a guardian, or an individual acting as a parent or guardian in the absence of the student's parent or guardian. The District may presume that the parent has the authority to inspect and review education records relating to his or her child unless the District has been advised that the parent does not have authority under applicable law.

D. *Education records* - Any information directly related to a student recorded in any way including, but not limited to, handwriting, print, computer media, video or audio tape, film, microfilm or microfiche, that is maintained by the District, an employee of the District, or any agent of the District except:

1. Personal records kept by an employee of the District that meets the following tests:

a. It is used only as a personal memory aid.

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b. It is kept in the personal possession of the individual who made it.

c. It is not accessible and has never been revealed to any other person except the employee's temporary substitute.

2. Medical treatment records maintained for "eligible students."

3. Records collected and maintained by a law enforcement unit of the school.

4. Records containing only information about a person after that individual is no longer a student in the District.

5. An employment record that is used only in relation to a student's employment by the District. (*Employment for this purpose does not include activities for which a student receives a grade or credit in a course.*)

6. Related alumni records after the student no longer attends classes provided by the District, and the records do not relate to the person as a student.

E. *Personally identifiable information* - Any data or information that makes the subject of a record known. This includes the student's name, the name(s) of the student's parent(s) or other family member(s), the student's address, the student's Social Security number, a student number, a list of personal characteristics, or other information that would make the student's identity easily traceable.

F. *Signed and dated written consent* - May include a record and signature in electronic form that:

1. Identifies and authenticates a particular person as the source of the electronic consent.

2. Indicates such person's approval of the information contained in the electronic consent.

Locations of Education Records

A list of types and locations of education records collected, maintained, or used will be provided to the parents on request [34 C.F.R. 300.616]. See Exhibit JR-EA.

Procedure to Inspect Education Records

Parents of a student, the designated representative of the parents, and an eligible student may inspect and review the student's education records that are collected, maintained, or used by the District [34 C.F.R. 300.501]. In some circumstances it may be mutually more convenient for the record custodian to provide copies of records. Charges for the copies of records will be costs of copying unless the fee would effectively prevent the parent from exercising rights to inspect and review those records [34 C.F.R. 300.613 and 300.617].

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Since a student's records may be maintained in several locations, the school principal will offer to collect copies of records or the records themselves from locations other than a student's school so they may be inspected at one (1) site. However, if parents and eligible students wish to inspect records where they are maintained, the school's principal will make every effort to accommodate their wishes.

Parents, the designated representative of the parents, or the eligible student should submit to the student's school principal a signed and dated written request that identifies as precisely as possible the record or records wanted for inspection. The District will respond to any request without unnecessary delay before any meeting regarding any individual education program or hearing relating to the identification, evaluation, placement of a student, or the provision of a free appropriate public education, and in no case more than forty-five (45) days after the request has been made [34 C.F.R. 300.613 and 99.10]. See Exhibit JR-ED.

The principal, or other education records custodian, will contact the parent of the student or the eligible student to discuss how access will be best arranged (e.g., copies, at the exact location, or records brought to a single site).

Parents have the right, upon reasonable request, for explanations and interpretations of the information contained in the records and a right to request copies of the records containing the information, if not in violation of stated policy of FERPA. Parents have the right to have a representative of the parent to inspect and review the records [34 C.F.R. 300.613 and 99.10].

The principal, or other education records custodian, will make the needed arrangements as promptly as possible and notify the parent or eligible student of the time and place where the records may be inspected. This procedure must be completed in forty-five (45) days or less after receipt of the request for access [34 C.F.R. 300.613].

If for any valid reason, such as working hours, distance between record location sites, or health, the parent or eligible student cannot personally inspect and review a student's education records, the District will arrange for the parent or eligible student to obtain copies of the record. See below for information regarding fees for copies of records [34 C.F.R. 300.613 and 99.10].

When a record contains information about students other than a parent's child or the eligible student, the parent or eligible student may not inspect and review the records of the other students [34 C.F.R. 300.615, 99.5 and 99.12].

Child Safety Caseworker

If a request is received from a Department of Child Safety caseworker, a school shall, per FERPA:

A. Identify to the caseworker any school that has requested a student's educational records and any person who has withdrawn a student from school, based on educational records.

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B. Provide the caseworker with any other requested information or records relating to a student who is or was enrolled at the school

A school may not prohibit any school employee, contractor or volunteer from speaking to a Department of Child Safety caseworker who is investigating an allegation of abuse or neglect.

Fees for Copies of Records

All records subject to disclosure under this procedure shall be available for inspection free of charge. If copies are desired, they shall be furnished by the District to the parent or eligible student on request and free of charge. Additional copies may be sent to other schools or agencies without charge. However, the District reserves the right to charge up to thirty-five cents (35¢) per page for multiple or excessive requests. Copies of available records shall be produced as promptly as possible upon receipt of the request. No fee will be charged for search and retrieval of records [34 C.F.R. 300.617 and 99.11].

The District will provide copies of records:

A. When the refusal to provide copies effectively denies access to the records by the parent or eligible student [34 C.F.R. 300.617].

B. At the request of the parent or eligible student, when the District has provided the records to third parties by the prior consent of the parent or eligible student.

C. At the request of the parent or eligible student when the District has forwarded the records to another school where the student seeks or intends to enroll.

Directory Information

Personally Identifiable Information

The District designates the following personally identifiable information contained in a student's education records as "directory information" and may disclose that information without prior written consent [20 U.S.C. 1232g(a)(5)(A)]:

A. The student's name.

B. The student's address.

C. The student's telephone listing.

D. The student's date and place of birth.

E. The student's electronic mail address.

F. The student's photograph.

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G. The student's grade level.

H. The student's major field of study.

I. The student's dates of attendance.

J. The student's enrollment status (e.g., part time or full time).

K. The student's participation in officially recognized activities and sports.

L. The student's weight and height if a member of an athletic team.

M. The student's honors and awards received.

N. The student's most recently attended educational agency or institution.

Within the first three (3) weeks of each school year the District will publish in a District communication or send home with each student the above list, or a revised list, of the items of directory information designated as directory information. For a student who enrolls after the notice is published, the list will be given to the parent or eligible student at the time and place of enrollment. See Exhibit JR-EB.

After the parents or eligible student have been notified, they will have two (2) weeks to advise the District in writing (a letter to the Superintendent's office) of any or all of the items they refuse to permit the District to designate as directory information about that student.

According to state and federal law if the Governing Board permits the release of directory information relating to students to persons or organizations who inform students of educational or occupational opportunities, then the Governing Board shall provide access to directory information on the same basis to military official recruiting representatives for the purpose of informing students of educational and occupational opportunities available to them.

Refusal to Release Personally Identifiable Information

Directory information shall be released on or before October 31 of each year unless the parent or eligible student requests in writing to the District (a letter to the Superintendent's office within two [2] weeks after notification) not to release directory information to any person or organization without prior signed and dated written consent. The District shall distribute a form, separate from any other form, designed and provided to districts by the Arizona Department of Education allowing students to request that directory information not be released. If the District distributes materials to students through electronic communication or on an internet website, the form may be distributed in the same manner.

A person who is wrongfully denied access to directory information or access to school buildings, school grounds or other property may notify the Department of Education, which shall report the alleged violation to the United States Department of Education. If the

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parent or eligible student refuses to allow the release of directory information without prior signed and dated written consent, then the District will not provide military recruiters, upon request, directory information containing the student's name, addresses and telephone listings.

Permission to Release Personally Identifiable Information

At the end of the two (2)-week period, if the parent or eligible student has not returned the form indicating refusal to allow the release of directory information, the District will assume it has their permission to release the above-mentioned information. The Governing Board shall provide the student with a transcript release form that allows the student to designate in separate check boxes whether the transcript is to be released to postsecondary institutions, the militia of this state or the armed services of the United States, or to any combination of these entities.

This designation will remain in effect until it is modified by the prior signed and dated written direction of the parent or eligible student. The student's records will be appropriately marked by the records custodian to ensure compliance with the parents' or eligible student's request.

Use of Student Education Records

To carry out their responsibilities, school officials will have access to student education records for legitimate educational purposes. The District will use the following criteria to determine who are school officials [34 C.F.R. 99.31]:

A. A person duly elected to the Board (under limited circumstances).

B. A person certificated by the state and appointed by the Board to an administrative or supervisory position.

C. A person certificated by the state and under contract to the Board as an instructor.

D. A person employed by the Board as a temporary substitute for administrative, supervisory, or instructional personnel for the period of such performance as a substitute.

E. A person employed by or under contract to the Board to perform a special task, such as a secretary, a clerk, the Board attorney, or auditor, for the period of such performance as an employee or contractor.

District officials who meet the criteria listed above will have access to a student's records if they have a legitimate educational interest in doing so [34 C.F.R. 99.32]. A "legitimate educational interest" is the person's need to know in order to:

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A. Perform an administrative task required in the school employee's position description approved by the Board.

B. Perform a supervisory or instructional task directly related to the student's education.

C. Perform a service or benefit for the student or the student's family, such as health care, counseling, student job placement, or student financial aid.

Records of students placed in special educational programs will be under the direct supervision of the program administration. All persons collecting or using personally identifiable information in records of students determined to be a student with a disability will receive training or instruction regarding Arizona's policies and procedures for the protection of these records at the collection, storage, disclosure, and destruction stages in accordance with FERPA and IDEA [34 C.F.R. 300.623].

The District will maintain for public inspection a current listing of the names and positions of employees who have access to personally identifiable information maintained on students placed in special education [34 C.F.R. 300.623]. When the information maintained in these records is no longer needed to provide educational services to the student, the District will notify the parents of their right to have the personally identifiable information destroyed [34 C.F.R. 300.624]. However, a permanent record of a student's name, address, phone number, grades, attendance record, classes attended, grade level completed, and year completed will be maintained [34 C.F.R. 300.624]. Destruction of records will be accomplished in accordance with the requirements of Arizona law and regulations of the Department of Library, Archives, and Public Records [34 C.F.R. 300.623].

The District will release information from or permit access to a student's education records only with a parent's or eligible student's prior signed and dated written consent, except that the Superintendent or a person designated in writing by the Superintendent may permit disclosure [34 C.F.R. 99.30, 99.31, 99.34, and 99.37]:

A. When a student seeks or intends to enroll in another school district or a postsecondary school the District will not further notify parents or eligible students prior to such a transfer of records. Parents and student have a right to obtain copies of records transferred under this provision. See Exhibit JR-EC.

B. When certain federal and state officials need information in order to audit or enforce legal conditions related to federally supported education programs in the District.

C. To parties who provide or may provide financial aid to a student to:

1. Establish the student's eligibility for the aid.

2. Determine the amount of financial aid.

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3. Establish the conditions for the receipt of the financial aid.

4. Enforce the agreement between the provider and the receiver of financial aid.

D. If a state law adopted before November 19, 1974, required certain specific items of information to be disclosed in personally identifiable form from student records to state or local officials.

E. If a state law adopted before November 19, 1974, required certain specific items of information to be disclosed in personally identifiable form from student records to state or local officials of the juvenile justice system and the officials certify in writing that the information will not be disclosed to any other party, except as provided under state law, without prior signed and dated written consent of the parent or the eligible student.

F. When the District has entered into a written agreement or contract for an organization to conduct studies on the District's behalf to develop tests, administer student aid, or improve instruction.

G. To accrediting organizations to carry out their accrediting functions.

H. To parents of an eligible student if the parents claim the student as a dependent as defined by the Internal Revenue Code of 1954.

I. To comply with a judicial order or lawfully issued subpoena. The District will make a reasonable effort to notify the parent or the eligible student before making a disclosure under this provision unless directed otherwise by a court of competent jurisdiction.

J. To comply with an *ex parte* order from a court of competent jurisdiction requiring the District to permit the U.S. Attorney General or U.S. Attorney General's designee to collect education records in the possession of the District that are relevant to an authorized investigation or prosecution of an offense listed in 18 U.S.C. 2332b(g)(5)(B) for an act of domestic or international terrorism as defined in 18 U.S.C. 2331. An *ex parte* order is an order issued by a court of competent jurisdiction without notice to the adverse party. A disclosure pursuant to an *ex parte* order will not be recorded as a disclosure of information from a student's education records by the District.

K. If the District initiates legal action against a parent or student, the District may disclose to the court, without a court order or subpoena, the education records of the student that are relevant for the District to proceed with the legal action.

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L. If a parent or eligible student initiates legal action against the District, the District may, without a court order or subpoena, disclose the student's education records that are relevant for the District to defend itself.

M. To comply with the request of authorized law enforcement officials conducting an investigation of acts of terrorism.

N. The disclosure is in connection with a health or safety emergency. Time is an important and limiting factor in determining whether the disclosure is in connection with a health or safety emergency. The District will permit any school official to make the needed disclosure from student education records in a health or safety emergency if:

1. The official deems the disclosure is warranted by the seriousness of the threat to the health or safety of the student or other persons.

2. The information is necessary and needed to address the emergency.

3. The persons to whom the information is to be disclosed are qualified and in a position to deal with the emergency.

O. The District may release student attendance, disciplinary, and other education records to a law enforcement agency and county attorney pursuant to an intergovernmental agreement between the District, the law enforcement agency, the county attorney, and other state, local, or tribal government agencies to create a local or tribal juvenile justice network for the purpose of:

1. providing appropriate programs and services to intervene with juveniles currently involved in the juvenile justice system.

2. providing appropriate programs and services designed to deter at-risk juveniles from dropping out of school or other delinquent behavior.

3. increasing the safety and security of the community and its children by reducing juvenile crime.

P. Education records provided pursuant to an intergovernmental agreement entered into in accord with the above provisions shall be used solely for the purposes of the agreement and shall not be disclosed to any other party, except as provided by law.

A District school official may release information from a student's education records, other than directory information, to a third party if the parent or the eligible student gives prior signed and dated written consent for the disclosure and the third party agrees that the

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information will not be disclosed to any other party without the prior consent of the parent or eligible student. The signed and dated written consent must include at least:

A. A specification of the records to be released.

B. The reasons for the disclosure.

C. The person or the organization or the class of persons or organizations to whom the disclosure is to be made.

D. The signature of the parent or eligible student.

E. The date of the consent and, if appropriate, a date when the consent is to be terminated.

The parent or the eligible student may obtain a copy of any records disclosed under this provision, unless otherwise provided.

Records of Requests for Access and Disclosures Made from Education Records

The District will maintain an accurate record of all requests for it to disclose information from or to permit access to a student's education records, and of information it discloses and access it permits, with some exceptions as listed below. This record will be kept with, but will not be a part of, each student's cumulative school records. It will be available only to the record custodian, the eligible student, the parent of the student, or to federal, state, or local officials for the purpose of auditing or enforcing federally supported educational programs [34 C.F.R. 99.32]. See Exhibit JR-EE.

The record will include at least:

A. The name of the person, organization or agency that made the request.

B. The interest the person, organization or agency had in the information.

C. The date the person, organization or agency made the request.

D. Whether the request was granted and, if it was, the date access was permitted or the disclosure was made.

The District will maintain this record as long as it maintains the student's education records. The record will not include requests for access or access granted to:

A. the parent or eligible student,

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B. authorized law enforcement officials conducting an investigation of acts of terrorism,

C. school officials who have a legitimate educational interest in the student,

D. requests for or disclosures of information contained in the student's education records if the request is accompanied by or authorized by the prior signed and dated written consent of the parent or eligible student, or

E. for requests for or disclosures of directory information designated for that student.

Procedures to Seek to Correct Education Records [34 C.F.R. 99.20 and 99.21]

Parents of students and eligible students have a right to seek to change any part of the student's record they believe is inaccurate, misleading, or in violation of student rights [34 C.F.R. 300.618 and 99.20]. (*Note*: Under the FERPA, the District may decline to consider a request to change the grade a teacher assigns for a course.)

For the purpose of outlining the procedure to seek to correct education records, the term *incorrect* will be used to describe a record that is inaccurate, misleading, or in violation of student rights. The term *correct* will be used to describe a record that is accurate, not misleading, and not in violation of student rights. Also, in this section, the term *requester* will be used to describe the parent of a student or the eligible student who is asking the District to correct a record.

To establish an orderly process to review and correct education records for a requester, the District may make a decision to comply with the request for change at several levels in the procedure [34 C.F.R. 300.618 and 99.20].

First-level decision. A parent of a student or an eligible student who finds an item in the student's education records that appears to be inaccurate, misleading, or in violation of student rights should immediately ask the record custodian to correct it. If the record is incorrect because of an obvious error and it is a simple matter to make the record change at this level, the record custodian will make the correction. However, if the record is changed at this level, the method and result must satisfy the requester.

If the custodian cannot change the record to the requester's satisfaction or the record does not appear to be obviously incorrect, the custodian will:

A. Provide the requester a copy of the questioned record at no cost.

B. Ask the requester to initiate a written request for the change.

C. Follow the procedure for a second-level decision.

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Second-level decision. The written request to correct a student's education records through the procedure at this level should specify the correction the requester wishes the District to make. It should at least identify the item thought to be incorrect and state whether the requester believes the item:

A. Is inaccurate and why,

B. Is misleading and why, or

C. Violates student rights and why.

The request will be dated and signed by the requester.

Within two (2) weeks after receiving a written request, the record custodian will study the request, discuss it with other school officials (the person who made the record or those who may have a professional concern about the District's response to the request), make a decision to comply or decline to comply with the request, and complete the appropriate steps to notify the requester or move the request to the next level for a decision.

If, as a result of this review and discussion, a decision is reached that the record should be corrected, the record custodian will affect the change and notify the requester, in writing, of that action. Each such notice will include an invitation for the requester to inspect and review the student's education records to make certain the record is in order and the correction is satisfactory.

If a decision is reached that the record is correct, the custodian will make a written summary of any discussions with other officials and of the findings in the matter. This summary and a copy of the written request will be transmitted to the Superintendent.

Third-level decision. The Superintendent will review the material provided by the record custodian and, if necessary, discuss the matter with other officials such as the school attorney or the Board (in executive session unless otherwise requested by parent[s]). The Superintendent will then make a decision concerning the request and complete the steps at this decision level. Ordinarily, this level of the procedure should be completed within two (2) weeks. If it will take longer, the Superintendent will notify the requester in writing of the reasons for the delay and a date when the decision will be made.

If the Superintendent decides the record is incorrect and should be changed, the record custodian will be advised to make the changes. The record custodian will advise the requester of the change.

If the Superintendent decides the record is correct, a letter to the requester will be prepared that will include [34 C.F.R. 300.619 and 99.20]:

A. The District's decision that the record is correct and the basis for the decision.

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B. A notice to the requester explaining the requester's right to ask for a hearing to present evidence that the record is incorrect and that the District will grant such a hearing.

C. Instructions for the requester to contact the Superintendent to discuss acceptable hearing officers, convenient times, and a satisfactory site for the hearing. (The District will not be bound by the requester's positions on these items but will, as far as possible, arrange the hearing as the requester wishes.)

D. Advice that the requester may be represented or assisted in the hearing by other parties, including an attorney, at the requester's expense.

Fourth-level decision. After the requester has submitted (orally or in writing) any wishes concerning the hearing officer and the time and place for the hearing, the Superintendent will, within one (1) week, notify the requester when and where the District will hold the hearing and whom it has designated as the hearing officer [34 C.F.R. 300.621, 99.21, 99.22, and 99.34].

At the hearing, the hearing officer will provide the requester a full and reasonable opportunity to present material evidence and testimony to demonstrate that the questioned part of the student's education records is incorrect as shown in the requester's written request for a change in the record (second level).

Within one (1) week after the hearing, the hearing officer will submit to the Superintendent a written summary of the evidence submitted at the hearing. Along with the summary, the hearing officer will submit recommendations, based solely on the evidence presented at the hearing, that the record should be changed or should remain unchanged.

The Superintendent will prepare the District's decision within two (2) weeks after the hearing. That decision will be based on the summary of the evidence presented at the hearing and on the hearing officer's recommendation. However, the District's decision will be based solely on the evidence presented at the hearing. Therefore, the Superintendent may overrule the hearing officer if the hearing officer's recommendation is deemed inconsistent with the evidence presented. As a result of the District's decision, the Superintendent will take one (1) of the following actions:

A. If the decision is that the District will change the record, the Superintendent will instruct the record custodian to correct the record. The record custodian will correct the record and notify the requester at the second-level decision [34 C.F.R. 300.620 and 99.21].

B. If the decision is that the District will not change the record, the Superintendent will prepare a written notice to the requester that will include [34 C.F.R. 300.620 and 99.21]:

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1. The District's decision that the record is correct and will not be changed.

2. A copy of a summary of the evidence presented at the hearing and a written statement of the reasons for the District's decision.

3. Advice to the requester that an explanatory statement may be placed in the student's education records stating the reasons for disagreement with the District's decision and/or the reasons for believing the record to be incorrect.

Final administrative step in the procedure. When the District receives an explanatory statement from a requester after a hearing, it will maintain that statement as part of the student's education records as long as it maintains the questioned part of the record. The statement will be attached to the questioned part of the record and whenever the questioned part of the record is disclosed the explanatory statement will also be disclosed [34 C.F.R. 300.620 and 99.21].

Annual Notification to Parents Regarding Confidentiality of Student Education Records [34 C.F.R. 300.612]

Dear Parent:

The Family Educational Rights and Privacy Act (FERPA) affords parents and students over 18 years of age ("eligible students") certain rights with respect to the student's education records. The Governing Board has established written policies regarding the collection, storage, retrieval, release, use, and transfer of student educational information collected and maintained pertinent to the education of all students to ensure the confidentiality of the information and to guarantee parents' and students' rights to privacy. These policies and procedures are in compliance with:

The Family Education Rights and Privacy Act; Title 20, United States Code, Sections 1232g and 1232h; and the Federal Regulations (34 C.F.R., Part 99) issued pursuant to such act;

Uniting and Strengthening America by Providing Appropriate Tools Required to Intercept and Obstruct Terrorism Act of 2001 (USA PATRIOT ACT);

Every Student Succeeds Act of 2015 (ESSA);

The Individuals with Disabilities in Education Act; 20 U.S.C. Chapter 33; and the Federal Regulations (34 C.F.R. Part 300); and

Arizona Revised Statutes, Title 15, sections 141 and 142.

Student education records are collected and maintained to help in the instruction, guidance, and educational progress of the student, to provide information to parents and staff members, to provide a basis for the evaluation and improvement of school programs, and for legitimate educational research. The students' records maintained by the District may include - but are not necessarily limited to, identifying data, report cards and transcripts of

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academic work completed, standardized achievement test scores, attendance data, reports of psychological testing, health data, teacher or counselor observations, and verified reports of serious or recurrent behavior patterns.

These records are maintained in the office of the District under the supervision of the school administrator and are available only to the teachers and staff members working with the student. Upon request, the District discloses education records, including disciplinary records, without consent to officials of another school district in which a student seeks or intends to enroll. Otherwise, records are not released to most agencies, persons or organizations without prior signed and dated written consent of the parent [34 C.F.R. 99.7]. The signed and dated written consent may be in electronic form under certain conditions [34 C.F.R. 99.30].

You shall be informed when personally identifiable information collected, maintained, or used is no longer needed to provide educational services to your child. The information must be maintained for two (2) years after the date your child was last enrolled in this school district.

You have the right to inspect and review any and all records related to your child within forty-five (45) days of the day of receiving a request for access, including a listing of persons or organizations who have reviewed or have received copies of the information [34 C.F.R. 99.7]. Parents who wish to review their children's records should contact the principal for an appointment or submit to the principal a written request that identifies the record(s) you wish to inspect. District personnel will make arrangements for access and notify you of the time and place where the records may be inspected. District personnel will be available to explain the contents of the records to you. Copies of student education records will be made available to parents when it is not practicable for you to inspect and review the records at the school. Charges for the copies of records will be costs of copying unless the fee prevents the parent from exercising rights to inspect and review those records.

You have the right to request that an amendment be made to the student's education records and to add comments of your own if you believe information in the record file is inaccurate or misleading [34 C.F.R. 99.7(a)(1)]. You should write the principal, clearly identify the part of the record you want changed, and specify why it is inaccurate or misleading. If the District decides not to amend the record as requested by you, the District will notify you of the decision and advise you of the right to a hearing regarding the request for amendment. Additional information regarding the hearing procedures will be provided to you when notified of the right to a hearing.

You have the right to consent to disclosures of personally identifiable information contained in the student's education records, except to the extent that FERPA authorizes disclosure without consent. One exception, which permits disclosure without consent, is disclosure to school officials with legitimate educational interests. A school official is a person employed by the District as an administrator, supervisor, instructor, or support staff member (including health or medical staff and law enforcement unit personnel); a person serving on the School Board; a person or company with whom the District has contracted to perform a

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special task (such as an attorney, auditor, medical consultant, or therapist); or a parent or student serving on an official committee, such as a disciplinary or grievance committee, or assisting another school official in performing his or her tasks. A school official has a legitimate educational interest if the official needs to review an education record in order to fulfill his or her professional responsibility.

Copies of the District student education records confidentiality policies and procedures may be reviewed in the assigned office in each school [34 C.F.R. 99.7]. You have the right to file a complaint under 34 C.F.R. 99.63 and 99.64 with the ~~Family Educational Rights and Privacy Act Office~~ U.S. Department of Education in Washington, D.C., concerning alleged failures by the District to comply with the requirements of FERPA [34 C.F.R. 99.7]. ~~The name and address of the Office that administers FERPA are:~~

~~**Family Policy Compliance Office**~~
~~**U.S. Department of Education**~~
~~**400 Maryland Avenue, SW**~~
~~**Washington, DC 20202-4605**~~

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ADVISORY 1064

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PUBLIC CONDUCT ON SCHOOL PROPERTY

No person shall engage in conduct that may cause interference with or disruption of an educational institution. Interference with or disruption of an educational institution includes any act that might reasonably lead to the evacuation or closure of any property of the educational institution or the postponement, cancellation or suspension of any class or other school activity. For the purposes of this policy, an actual evacuation, closure, postponement, cancellation or suspension is not required for the act to be considered interference or disruption.

Interference or Disruption

A person commits interference with or disruption of an educational institution by doing any of the following:

A. Intentionally, knowingly or recklessly interfering with or ~~disruption of~~ disrupting the normal operations of an educational institution by either:

1. Threatening to cause physical injury to any employee or student of an educational institution or any person on the property of an educational institution.

2. Threatening to cause damage to ~~the District,~~ District property ~~of the District~~, or the property of any ~~person attending the~~ District employee or student.

B. Intentionally or knowingly entering or remaining on the property of an educational institution for the purpose of interfering with ~~or denying~~ the lawful use of the property or in any manner that denies or interferes with the lawful use of the property ~~to~~ by others.

C. Intentionally or knowingly refusing to obey a lawful order given by the Superintendent or a person designated to maintain order.

The ~~above~~ threats identified ~~acts~~ in item A above need not be directed at a specific individual, the District, or specific property of the District to constitute a violation of this policy and Arizona law.

Restitution

Restitution for any financial loss caused by a violation of the policy may be required. Furthermore, an individual who interferes with or disrupts an educational institution is subject to misdemeanor or felony charges as provided in A.R.S. 13-2911.

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~~A person may also interfere with or disrupt the District function by committing any of the following:~~

~~A. Any conduct intended to obstruct, disrupt, or interfere with teaching, research, service, administrative, or disciplinary functions or any activity sponsored or approved by the Board.~~

~~B. Physical or verbal abuse or threat of harm to any person on property owned or controlled by the District or at supervised functions sponsored by the District.~~

~~C. Forceful or unauthorized entry to or occupation of District facilities, including both buildings and grounds.~~

~~D. Illicit use, possession, distribution, or sale of tobacco, alcohol, or drugs, other controlled substances, or other illegal contraband on District property or at school-sponsored functions.~~

~~E. Use of speech or language that is offensive or inappropriate to the limited forum of the public school educational environment.~~

~~F. Failure to comply with the lawful directions of District officials or of District security officers or other law enforcement officers acting in performance of their duties, and failure to identify oneself to such officials or officers when lawfully requested to do so.~~

~~G. Knowing violation of a District rule and regulation. Proof that an alleged violator has a reasonable opportunity to become aware of such rules and regulations shall be sufficient proof that the violation was done knowingly.~~

~~H. Any conduct constituting an infraction of any federal, state, or city law or policy or regulation of the Board.~~

~~I. Carrying or possessing a weapon on school grounds unless the individual is a peace officer or has obtained specific authorization from the appropriate school administrator.~~

Additional Requirements of the General Public

For purposes of this policy, ~~The definition of~~ *general public* ~~is~~ means any~~one~~ person who ~~does~~ is not ~~come under the definition of~~ a District student, faculty member, staff member, or employee.

A. No person shall visit or audit a classroom or other school activity, nor shall any person come upon or remain upon school premises, without approval by the principal or the principal's authorized representative. Nor shall any person conduct or attempt to conduct any activity on school premises without prior approval by the Superintendent or the Superintendent's authorized representative.

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~~B. Any member of the general public considered by the Superintendent, or a person authorized by the Superintendent, to be in violation of these rules shall be instructed to leave the property of the District. Failure to obey the instruction may subject the person to criminal proceedings pursuant to A.R.S. 13-2911 and to any other applicable civil or criminal proceedings, or to tribal ordinance.~~

B. ~~C.~~ Persons attending special functions shall confine themselves to the specific part of the facility assigned in the permit.

C. ~~D.~~ Persons who engage in disorderly conduct ~~of any kind~~ pursuant to A.R.S. 13-2904 may be subject to removal and exclusion from the facility.

D. ~~E. The use of facilities shall be granted only for legitimate purposes. Therefore, the permit holder shall assume full responsibility for any unlawful act committed during the exercise of the permit~~ No person shall possess a deadly weapon on school grounds except as authorized by law.

E. ~~F.~~ No person shall possess or engage in the use of ~~medical~~ marijuana on District property, at a District event, or in a District vehicle.

If the Superintendent, or a person authorized by the Superintendent, has reasonable grounds to believe that any member of the general public is in violation of these rules, the member of the general public shall be instructed to leave the property of the District. Failure to obey the instruction may subject the person to criminal proceedings pursuant to A.R.S. 13-2911 and to any other applicable civil or criminal proceedings.

Adopted: _____

LEGAL REF.:
A.R.S.
13-2904
13-2905
13-2911
13-3102
15-108
15-341
15-507
36-2801 *et seq*.
36-2802
36-2851

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CROSS REF.:
GBEA – Ethics and Code of Conduct
~~GBEB - Staff Conduct~~
GCQF - Discipline, Suspension, and Dismissal ~~of Professional Staff Members~~
~~GDQD - Discipline, Suspension, and Dismissal of Support Staff Members~~
JIC - Student Conduct
JK - Student Discipline
KI - Visitors to Schools

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POLICY SERVICES
ALERTS

Volume 38, Number 1 **July 2026**

Summary

The following bills were approved by the governor and sent to the Office of the Secretary of State during April and June of 2026.

1. SB 1166 amended A.R.S. 15-305 to allow a county school superintendent to offer high school equivalency preparation instruction to enrolled accommodation school students in grades eleven or twelve who are at least sixteen years of age.

2. HB 2032 amended A.R.S. 15-741 and A.R.S. 15-743.

   A.R.S. 15-741 changes the date a contractor for statewide assessment testing must submit unofficial test scores from "on or before May 25" to "on or before May 26" of each academic year.

   A.R.S. 15-743 extends the testing window allowed for administering the statewide assessment from four to six consecutive school weeks, adds that any assessment given to students in grades three through eight may not begin before the second week of April, except for alternative assessments given pursuant to a student's Section 504 Plan or Individualized Education Program (IEP), removes the Arizona Department of Education's authority to adjust the statewide testing window.

3. HB 2203 directs the Arizona Department of Education (ADE) to review public school reporting requirements and identify repetitive and expired or obsolete reporting requirements. ADE shall submit recommendations to the legislature before December 1, 2026, to repeal, consolidate or modify school reporting requirements.

4. HB 2395 added A.R.S. 15-249.20, establishing the Arizona School Fitness Program within the Arizona Department of Education (ADE). This program recognizes public schools that choose to participate in a nationally recognized physical fitness test or event. ADE will provide participating schools with guidelines, best practices and resources. Schools that choose to participate may include this program designation in the school report card required by A.R.S. 15-746.

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5. HB 2621 amended A.R.S. 15-823 and A.R.S. 15-825.

   A.R.S. 15-823 adds new Subsection C which requires governing boards to admit students who are placed by a state placing agency or a court having jurisdiction within the boundaries of the District and who are in any of the following: 1) a state rehabilitation or correctional institution, 2) a foster home or child care agency or institution that is licensed by the Department of Child Safety or the Department of Health Services, 3) a residential facility that is operated or supported by the Department of Economic Security or the Department of Health Services, or 4) under the supervisor of the Department of Juvenile Corrections pursuant to the Interstate Compact on Juveniles.

   A.R.S. 15-825 revises the process for students who reside in unorganized territory by allowing a parent to contact an adjoining school district directly to request enrollment, rather than first enrolling the student and then applying for a Certificate of Educational Convenience (CEC). If a school district receives such a request, it shall enroll the student and shall submit a completed CEC to the county school superintendent, following the guidelines in A.R.S. 15-825, and may not delay Child Find activities, parental consent for special education evaluation or required timelines while the application is processing.

6. HB 2764 added A.R.S. 15-262, which directs the Superintendent of Public Instruction to establish a State Seal of Computer Science Proficiency Program. Any school district or charter school may choose to participate in this program. A school district or charter school that participates in this program shall award a qualifying high school graduating student a Seal of Computer Science Proficiency on the high school diploma.

   The State Board of Education will develop and adopt the minimum requirements for this program.

7. HB 4043 amended A.R.S. 15-120.07 to require, beginning August 1, 2027, each school district and charter school shall have on campus during school hours at least one employee who has successfully completed: 1) a nationally recognized course that follows cardiovascular care guidelines in cardiopulmonary resuscitation and first aid and 2) a nationally recognized course that follows cardiovascular care guidelines in the use of automatic external defibrillators, if the school has at least one automated external defibrillator on campus.

8. HB 4163 amended Section 7 to establish a Child Sexual Abuse and Assault Awareness and Prevention Pilot Program within the Arizona Department of Education (ADE) for the 2027–2028 school year. This program requires ADE to: 1) select six public schools to participate in the pilot program and to consult with the Department of Child Safety (DCS) and survivor-led organizations in developing the program and curriculum; 2) provide evidence-based training for teachers and educational resources for parents addressing the prevention,

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recognition, and reporting of child sexual abuse, assault, exploitation, grooming, and technology-facilitated abuse; and 3) develop and post educational materials and a model response policy for participating schools and to report to the Governor and Legislature on the pilot program.

Participating schools in the pilot program may not require parent participation and must provide parents with access to the educational materials. On or before October 1, 2028, participating schools shall submit a report to the ADE and DCS.

Section 9 was amended to provide the intent of the governor and legislature that school districts increase classroom spending over the previous year's percentages in the combined categories of instruction, student support and instructional support as prescribed by the auditor general.

9. **INFORMATION ITEMS**

9.A. **Requests for Future Agenda Items**

This agenda item is for the Governing Board to have a running record of potential items to be placed on future agendas. There will be no discussion on the substance, merits, or issues relating to the proposed agenda item.

9.B. **Upcoming Meetings and Events Calendar**

- Policy Work Session - September 18, 2026 at 1:00 p.m.
- Next Regular Board Meeting - October 13, 2026 at 6:00 p.m.

9.C. **Review of Possible Policy Changes to be Considered for Adoption at a Future Meeting**

See the attached Policy Advisory for policy changes to be considered. Policies affected: New regulation DJ-R Purchasing Ethics;Policy BCB - Board Member Conflict of Interest and its accompanying Exhibit BCB-E, and Policy GBEAA - Conflict of Interest and its accompanying Exhibit GBEAA-E.

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POLICY SERVICES

ADVISORY

Volume 38, Number 5 **August 2026**

Policy Advisory No. 1066.....*NEW* Regulation DJ-R — Purchasing Ethics

Summary

Policy Advisory Discussion

Policy Advisory No. 1066 Regulation DJ-R — Purchasing Ethics

Regulation DJ-R has been created to provide corresponding implementation requirements which incorporates new Uniform System of Financial Records (USFR) guidance, including procedures for authorized events, establishing expense limitations, and documenting authorized food and beverage purchases.

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If you have any questions, please call Policy Services at (602) 254-1100. Ask for Dr. Charlotte Patterson, Policy Analyst; Lynne Bondi, Policy Analyst; or Renae Watson, Policy Technician. Our e-mail addresses are, respectively, [cpatterson@azsba.org], [lbondi@azsba.org] and [rwatson@azsba.org].

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ADVISORY 1066

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REGULATION

PURCHASING ETHICS

(Events and Expense Limits of Food and Beverage Purchases for Board Members, Staff, Students, and Community)

District food and beverage purchases shall comply with Governing Board Policy DJ and advanced authorization by the Superintendent for the following events and expense limitations. Governing Board approval is required in advance of purchases outside of these parameters.

Events:

A. Governing Board meetings, workshops, and retreats, regardless of how titled.

B. Emergency operations that require employees to remain on duty after hours.

C. District leadership meetings.

D. New employee training and orientation.

E. District-sponsored employee training and professional development.

F. Employee recruitment activities and student recruitment fairs.

G. Beginning and end of year events.

H. Parent-Teacher Conferences.

I. Student activities approved by the Superintendent or designee.

Expense Limitations

Districts choose option 1 or option 2.

Option 1:

Food and beverages shall not exceed the limits set forth in the State of Arizona Accounting Manual (SAAM) for per-person and per-meal.

OR

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Option 2:

The following per-person dollar limits shall not be exceeded for food and beverages, including taxes, gratuities and/or delivery costs. (District enters amounts)

Breakfast $_____

Lunch $_____

Dinner $_____

Snacks and refreshments $_____

Other Limitations

Prior to each food and/or beverage purchase authorized by this regulation, the District fund or funds from which the purchase will be paid shall be identified in writing. No such purchase shall be paid from a District fund unless the expenditure of that fund for food and beverages is authorized by law.

To demonstrate compliance with the Arizona Constitution, applicable state law, the Uniform System of Financial Records, and Governing Board policy, the District shall prepare and maintain documentation for each food and/or beverage purchase authorized by this regulation and retained in accordance with the records retention schedules.

No District funds shall be expended for alcoholic beverages.

Delegation

Pursuant to Arizona Revised Statutes §15-341(F), the Governing Board delegates to the Superintendent the authority to prescribe any administrative procedures necessary to implement this regulation.

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POLICY SERVICES
ADVISORY

Volume 38, Number 6 **August 2026**

Policy Advisory No. 1067 .....Policy BCB — Board Member Conflict of Interest
Exhibit BCB-E — Board Member Conflict of Interest

Policy Advisory No. 1068 ..... Policy GBEAA — Conflict of Interest
Exhibit GBEAA-E — Conflict of Interest

Summary

The following policy advisories reflect updated requirements for Conflict of Interest (COI) in the 2027 Uniform System of Financial Systems (USFR) updates. Impacts include specific training requirements, disclosures, and maintenance of records.

Policy Advisory Discussion

Policy Advisory No. 1067 **Policy BCB — Board Member Conflict of Interest**
Exhibit BCB-E — Board Member Conflict of Interest

Policy BCB updates include board member requirements for annual training, filing Disclosure Forms, investigations, and maintenance of records.

BCB-E updates align the Disclosure Form with USFR guidance.

Policy Advisory No. 1068 **Policy GBEAA — Conflict of Interest**
Exhibit GBEAA-E — Conflict of Interest

Policy GBEAA updates include employee requirements for annual training, filing Disclosure Forms, investigations and remediation, and maintenance of records.

GBEAA-E updates align the Disclosure Form with USFR guidance.

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If you have any questions, call Policy Services at (602) 254-1100. Ask for Dr. Charlotte Patterson, Policy Analyst; Lynne Bondi, Policy Analyst; or Renae Watson, Policy Technician. Our e-mail addresses are, respectively, [cpatterson@azsba.org], [lbondi@azsba.org] and [rwatson@azsba.org]. You may also fax information to (602) 254-1177.

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ADVISORY 1067

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BOARD MEMBER CONFLICT OF INTEREST

Board Member Voting Restrictions

Notwithstanding any other provision of law, a Governing Board member shall be eligible to vote on any budgetary, personnel, or other question that comes before the Board, except that it is unlawful for a member to vote on a specific item that concerns the appointment, employment, or remuneration of the Board member or a Board member's spouse or dependent as defined in A.R.S. 43-1001 and in accordance with A.R.S. 15-323.

Employment Limitations

No dependent, as defined in A.R.S. 43-1001, of a Governing Board member may be employed in the District, except by consent of the Board in accordance with A.R.S. 15-502. Small school Districts, as defined by A.R.S. 15-901, are granted an exception regarding employment of substitute teachers. [A.R.S. 15-421(E)]

No employee of the District or the spouse of such employee may hold membership on the Governing Board of the District. Small school Districts, as defined by A.R.S. 15-901, are granted an exception regarding employment of substitute teachers. [A.R.S. 15-421]

Pursuant to A.R.S. 15-421, the District is allowed to employ, including through a third (3rd)-party contractor who provides services to the District, any person who served as a member of the School District Governing Board during the preceding two (2) years only in a position in which the person will provide services directly to students, including as a certificated, a substitute teacher, and an employee or contractor who provides transportation, instructional support, or student support services. The District is authorized to increase the time period for this restriction to be more than two (2) years.

Conflicts of Interest

The District shall annually provide conflict of interest training to all Board members. The training shall include information regarding the District's policies regarding conflicts of interest, what constitutes a substantial and remote interest under the applicable statute, the definition of relative pursuant to A.R.S. 38-502(9), how and when to complete the District's annual Conflict-of-Interest Disclosure Form, the requirements to refrain from discussion or voting on a matter in which they or a relative has a substantial interest, and the penalties for violating the applicable statutes.

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Each Board member shall annually complete and sign the District's Conflict-of-Interest Disclosure Form (BCB-E) and within fifteen (15) days of any change in circumstance. Board members shall complete and sign the Conflict-of-Interest Disclosure Form every January of their term and, if they are a new Board member, within five (5) days of starting their term. Evidence of the guidance provided and signed Disclosure Forms shall be maintained by the District in compliance with the Uniform System of Financial Records (USFR), and all disclosures shall be kept on file for public inspection as required by A.R.S. 38-509.

Any Board member or employee of the District who has, or whose relative has, a substantial interest in any contract, sale, purchase, or service to the District shall make known that interest in the official records of the District and shall refrain from voting upon or otherwise participating in any manner as a Board member or employee in such contract, sale, or purchase. [A.R.S. 38-503]

Any Board member or employee who has, or whose relative has, a substantial interest in any decision of the District shall make known such interest in the official records of the District and shall refrain from participating in any manner as a Board member or employee in such a decision. [A.R.S. 38-503]

"Refrain from participating in any manner" means more than just refraining from making a final decision. It means participating in any way in the process leading up to a decision. An employee with a conflict of interest must not make recommendations, give advice, or otherwise communicate in any manner with anyone involved in the decision-making process.

Investigations

The District will investigate allegations of inadequate disclosure of substantial interests and/or inappropriate participation in a Governing Board meeting or other discussions when a substantial interest may exist.

Purchases from Governing Board Members

School district procurement rules are required for all purchases of service from Governing Board members, regardless of the dollar amount. Purchases for services may only be made after public competitive bidding. Purchases of supplies, materials, and equipment from Board members are subject to the following:

A. Purchases less than one hundred thousand dollars ($100,000) comply with the Uniform System of Financial Records (USFR) guidelines and written quotations.

B. Purchases of one hundred thousand dollars ($100,000) and above comply with the school district procurement rules for public competitive bidding.

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Purchases from Governing Board Members for Districts with 3,000 or More Students:

A. Purchases for supplies, materials, and equipment are limited to three hundred dollars ($300) per transaction.

B. Total purchases within any twelve (12) month period are limited to one thousand dollars ($1,000).

C. The Board has, by majority vote, adopted or reconfirmed a policy authorizing such purchases within the preceding twelve (12) month period.

Purchases from Governing Board Members for Districts with Fewer than 3,000 Students:

A. Each purchase is approved by the Governing Board;

B. Although there is no limit on the amount of the purchase, the amount of the purchase is included in the Board's meeting minutes.

Filing of Disclosures

The District shall maintain in the District's official records and for public inspection in a special file all Board Member Conflict of Interest Disclosure Forms and all other documents necessary to memorialize all disclosures of substantial interest made known pursuant to the statutory conflict-of-interest provisions. [A.R.S. 38-509]

Adopted: _____

LEGAL REF.:
A.R.S.
15-213
15-323
15-421
15-502
38-481
38-503
38-509
43-1001
A.G.O.
I84-012
I87-035
I88-013
I06-002
Attorney General Arizona Agency Handbook, Chapter 8
Uniform System of Financial Records

CROSS REF.:
BBBA - Board Member Qualifications
DJE - Bidding/Purchasing Procedures

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BCB-E ©

EXHIBIT

BOARD MEMBER CONFLICT OF INTEREST

DISCLOSURE FORM

Governing Board members must file a Conflict of Interest Disclosure within five (5) calendar days after assuming office and at least annually thereafter, either identifying any substantial interest the board member or the board member's relative has or stating that neither the board member nor the board member's relative has any substantial interest requiring disclosure.

All Conflict of Interest Disclosure Forms shall be filed with _____ [*name District location/department*] and maintained in the District's official records in accordance with law.

It is the board member's responsibility to update and submit a revised Disclosure Form to the location/department noted above within fifteen (15) calendar days after any new substantial interest arises following the date of the most recent disclosure.

I, _____, do hereby indicate that:

~~1. That~~ I am presently a~~n officer/employee~~ District Governing Board Member of the _____ School District, and that;

A. I understand my responsibility for disclosing conflicts of interest as required by Arizona law and Policy BCB;

B. I understand the statutory consequences for noncompliance with conflict of interest in A.R.S. 38-510 and any additional consequences imposed in accordance with Policy BCB;

C. I agree to comply with all conditions and restrictions the District imposes regarding my involvement for which I or my relative have a conflict of interest;

D. I agree to submit an updated Disclosure Form for any changes to circumstances within fifteen (15) days.

_____ _____

Date Signature

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STATEMENT OF NO CONFLICT
To be completed only if you do not or your relative does not have a conflict of interest.

I, _____, do hereby indicate that I do not have, and none of my relatives has, a substantial interest in any contract, sale, purchase, service, decision, investigation, or other matter of the _____ School District.

_____
Date Signature

STATEMENT OF CONFLICT
To be completed only if you or your relative has a conflict of interest.

~~2. That~~ I (or my relative[s]: _____) have a substantial interest in the contract, sale, purchase, decision, investigation, or other matter by the _____ Governing Board as described below.

Identify the contract, sale, purchase, service, decision, investigation, or other matter in which you or your relative may have a "substantial interest" under A.R.S. §§ 38-501 to 511. (Use as much space as necessary.)

Describe the "substantial interest" referred to above. (Use as much space as necessary.)

STATEMENT OF DISQUALIFICATION FROM PARTICIPATING IN A GOVERNING BOARD MATTER
To be completed if you have a conflict as identified above with an item on a Governing Board Meeting Agenda.

To avoid any possible conflict of interest under A.R.S. §§ 38-501 to 511, I will refrain from participating in any manner ~~in the matter identified above~~ on Item _____ on the _____ (date) Governing Board Agenda because I or my relative has a conflict of interest in the matter. If I have not previously disclosed this conflict of interest, I will prepare and submit an updated Board Member Conflict of Interest Disclosure Form that provides the necessary information regarding my conflict.

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I understand that I should also orally indicate my conflict with the Agenda Item at the meeting, if I am in attendance, and then refrain from participating in any matter.

This Statement of Disqualification will be maintained with the minutes of the Governing Board meeting at which I have declared my conflict.

_____ _____

Date Signature

~~The District will investigate allegations of inadequate disclosure of substantial interests and/or inappropriate participation when a substantial interest may exist.~~

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ADVISORY 1068

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Employment of Close Relatives

The Superintendent, ~~P~~principals, or other administrators with hiring authority may not participate in the hiring of any person related to them within the third degree of consanguinity, affinity, or by law, and no District employee shall be placed in a position where they directly supervise or are directly supervised by such a relative.

No dependent, as defined in A.R.S. 43-1001 (see also Internal Revenue Code 26 U.S.C. 152), of a Governing Board member may be employed in the District, except by consent of the Board in accordance with A.R.S. 15-502. Small school Districts, as defined by A.R.S. 15-901, are granted an exception regarding employment of substitute teachers. A.R.S. 15-421(E).

This policy will apply for summer or part-time work as well as for full-time employment.

Business Relations

Any Governing Board member, administrator, or employee who has, or whose relative has, a substantial interest in any contract, sale, purchase, or service to the District shall make known that interest in the official records of the District, and shall refrain from participating in any manner as an employee in such contract, sale, or purchase, as provided in A.R.S. 38-501, 38-502 and 38-503.

Refrain from participating in any manner means more than just refraining from making a final decision. It means participating in any way in the process leading up to a decision. A Governing Board member, administrator, or employee with a conflict of interest must not make recommendations, give advice, or otherwise communicate in any manner with anyone involved in the decision-making process.

Vendor Relations

No employee of the District will accept a gift or benefit from any person, group, or entity doing, or desiring to do, business with the District as described in Policy DJ, Purchasing Ethics.

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District Purchases from Employees

The District must comply with competitive purchasing rules for any acquisition of goods or services from District employees regardless of the dollar amount. The District may only acquire equipment, material, supplies, or services from its employees under an award or contract after public competitive bidding (A.R.S. 38-503; A.G.O. I06-002). The requirement applies to any purchase using District monies, including extracurricular activities fees, tax credit contributions, and monies held in trust by the District such as student activities monies, when a District employee acts as the vendor.

Employee Guidance and Acknowledgement of Understanding

The District shall annually provide ~~written guidance~~ conflict of interest training to all employees. ~~regarding~~ The training shall include information regarding the District's policies regarding conflicts of interest, what constitutes a substantial and remote interest ~~and~~ under the applicable statute, the definition of relative pursuant to A.R.S. 38-502(9), how and when to complete the District's annual Conflict-of-Interest Disclosure Form, the requirement to refrain from participating in a matter in which they or a relative has a substantial interest, and the penalties for violating the applicable statutes.

Eeach employee shall annually complete and sign the District's Ceonflict-of-I~~i~~nterest D~~d~~isclosure F~~f~~orm (GBEAA-E) and within fifteen (15) days of any change in circumstance. Employees shall complete and sign the Conflict-of-Interest Disclosure Form every January of their employment and, if they are a new employees, within five (5) days of starting their employment with the District. Evidence of the guidance provided and signed disclosure forms shall be maintained by the District in compliance with the Uniform System of Financial Records (USFR), and all disclosures shall be kept on file for public inspection as required by A.R.S. 38-509.

Investigations and Remediation

The District will investigate allegations of inadequate disclosure of substantial interests and/or inappropriate participation when a substantial interest may exist.

When an employee has disclosed a substantial interest or when the District otherwise determines that an employee has a substantial interest, the Superintendent and other administrators as appropriate and necessary will determine what steps should be taken to remediate or eliminate the potential for the employee's improper influence on a District decision implicated by the substantial interest. The administration will document the remediation steps taken.

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Filing of Disclosures

The District shall maintain in the District's official records and for public inspection in a special file all Employee Conflict of Interest Disclosure Forms and all other documents necessary to memorialize all disclosures of substantial interest made known pursuant to the statutory conflict-of-interest provisions. [A.R.S. 38-509]

Adopted: _____

LEGAL REF.:
A.R.S.
15-213
15-323
15-421
15-502
38-481
38-501 - 38-511 (Title 38, Chapter 3, Article 8)
43-1001
A.G.O.
I82-004
I83-093
I83-111
I00-013
I03-005
I06-002
Attorney General Arizona Agency Handbook, Chapter 8~~, Appendix 8.1, Conflict of Interest Disclosure Memorandum~~
Uniform System of Financial Records
26 U.S.C. 152

CROSS REF.:
BCB - Board Member Conflict of Interest
DJ - Purchasing Ethics
DJE - Bidding/Purchasing Procedures
GBP – Reprisals

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EXHIBIT

CONFLICT OF INTEREST

CONFLICT OF INTEREST DISCLOSURE PURSUANT TO A.R.S. 38-501 to 38-511

(Instructions)

~~1.~~ Employees must file a Conflict of Interest Disclosure Form within five (5) calendar days after commencing work and at least annually thereafter, either identifying any substantial interest the employee or the employee's relative has or stating that neither the employee nor the employee's relative has any substantial interest requiring disclosure.

~~2.~~ All Conflict of Interest Disclosure~~s~~ Forms shall be filed with _____ [*name District location/department*] and maintained in the District's official records in accordance with law.

~~3.~~ It is the employee's responsibility to update and submit a revised Disclosure Form to the location/department noted above within fifteen (15) calendar days after any new substantial interest arises following the date of the most recent Disclosure. The District will investigate allegations of inadequate disclosure of substantial interests and/or inappropriate participation when a substantial interest may exist.

STATEMENT OF NO CONFLICT

To be completed only if neither you nor your relative has a substantial interest requiring disclosure.

I, _____, do hereby indicate that I do not have, and none of my relatives has, a substantial interest in any contract, sale, purchase, service, decision, investigation, or other matter of the _____ School District.

_____

Date Signature

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STATEMENT OF CONFLICT

I, _____, do hereby indicate:

~~1.~~ That I am presently an employee of the _____ School District;

~~2.~~ That I (or my relative[s]: _____) have a substantial interest in the contract, sale, purchase, decision, investigation, or other matter by the _____ Governing Board as described below.

Identify the contract, sale, purchase, service, decision, investigation, or other matter in which you or your relative may have a "substantial interest" under A.R.S. 38-501 to 38-511. (Use as much space as necessary)

Describe the "substantial interest" referred to above. (Use as much space as necessary)

To avoid any possible conflict of interest under A.R.S. 38-501 to 38-511, I will refrain from participating in any manner in the matter identified above.

_____ _____

Date Signature

~~STATEMENT OF DISQUALIFICATION~~

~~To be completed if you have a conflict as identified above.~~

~~To avoid any possible conflict of interest under A.R.S. 38-501 to 38-511, I will refrain from participating in any manner in the matter identified above.~~

_____ _____

~~Date~~ ~~Signature~~

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STATEMENT OF NO CONFLICT

To be completed only if neither you nor your relative has a substantial interest requiring disclosure.

I, _____, do hereby indicate that I do not have, and none of my relatives has, a substantial interest in any contract, sale, purchase, service, decision, investigation, or other matter of the _____ School District.

_____ _____

Date Signature

10. **ADJOURNMENT**