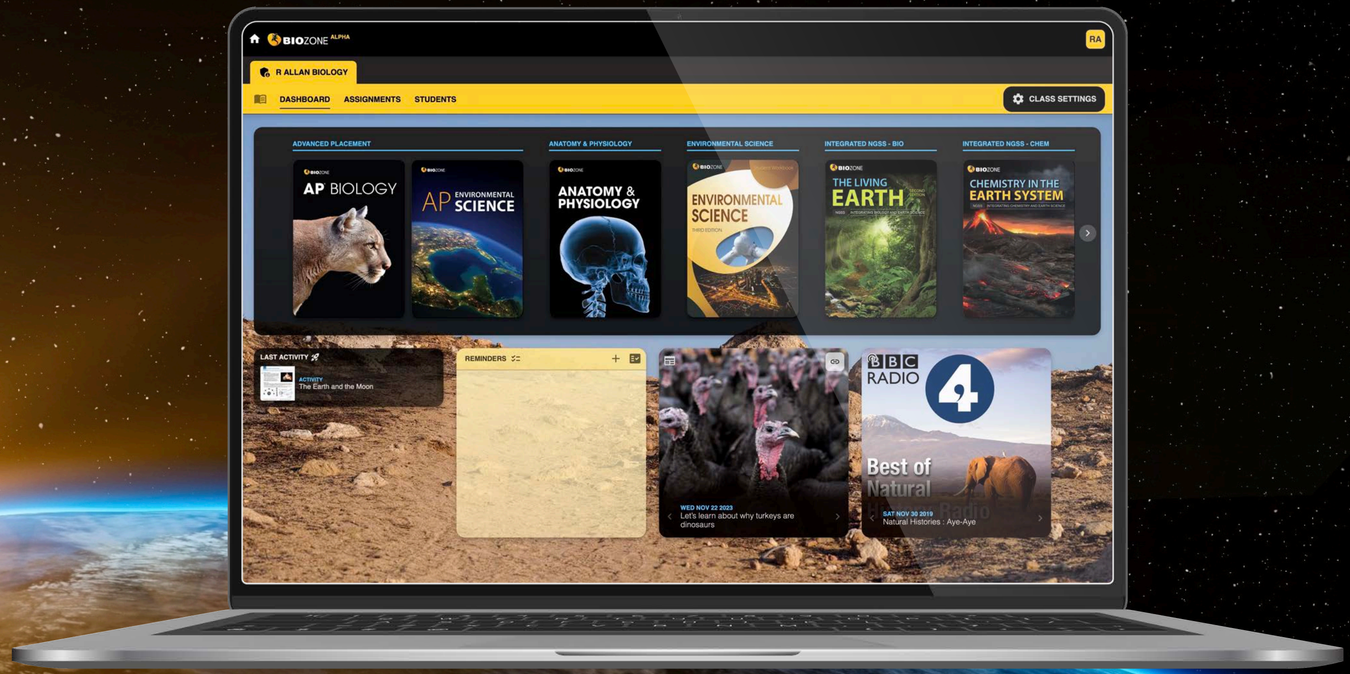


BIOZONE WORLD

Introducing:

Richard Allan

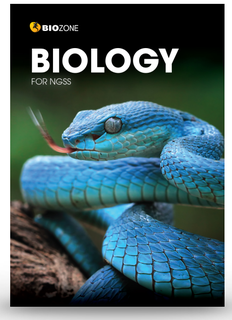
President

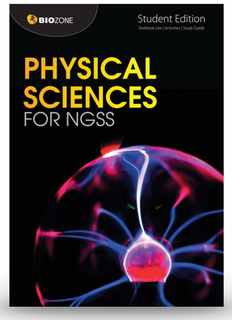
BIOZONE Corporation

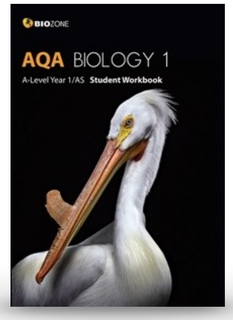
What Will be Covered:

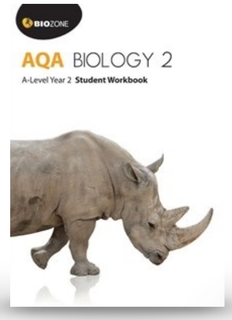
- Introduction:
    - Programs available
    - How to access FULL PREVIEWS
    - Explanation of the Worktext concept
- **BIOZONE** WORLD
    - Subscriptions
    - New Features in development
    - Digital resources included
- BIOZONE Virtual Science lab

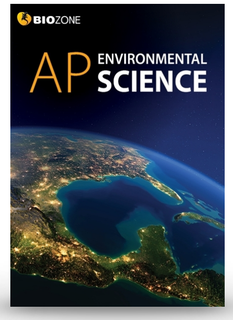
Our range of resources reflects our diverse market

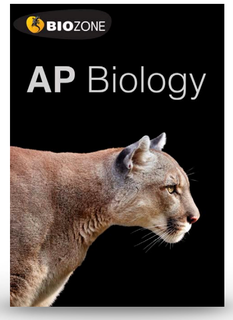


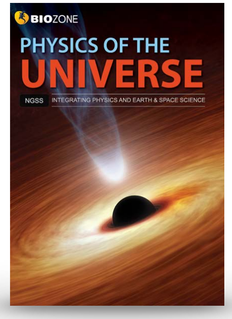


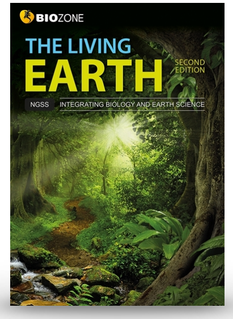


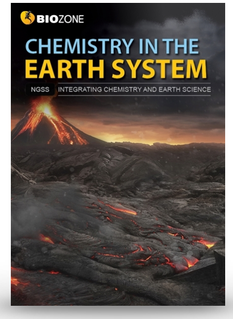


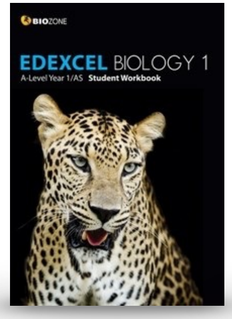


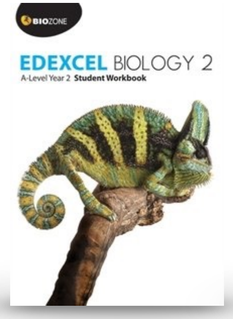


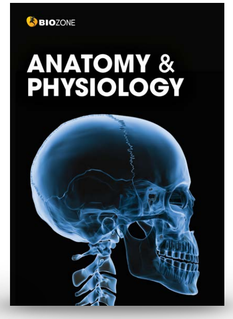


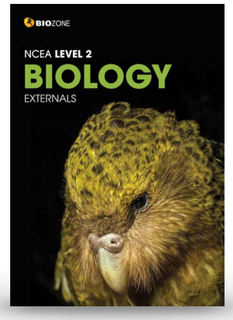


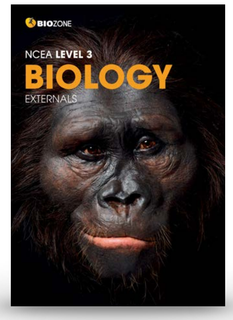


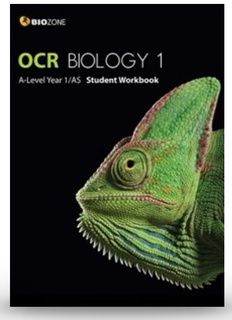


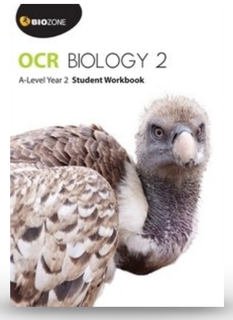


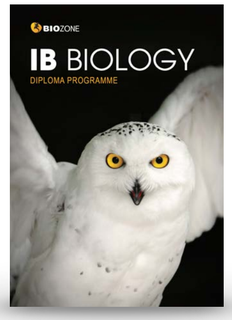


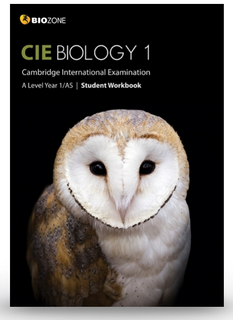








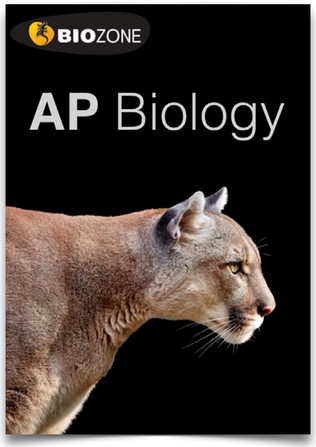


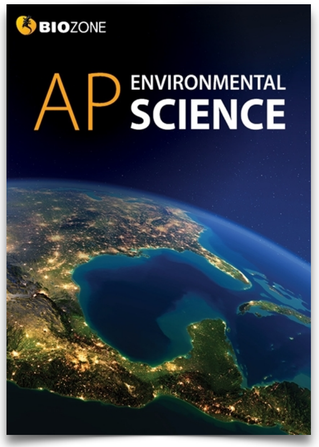


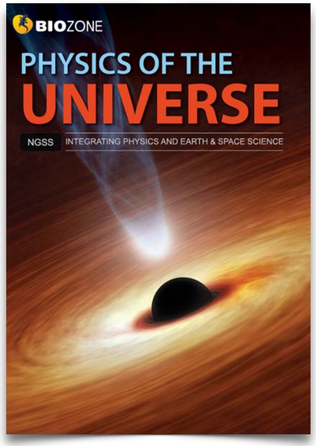
BIOZONE

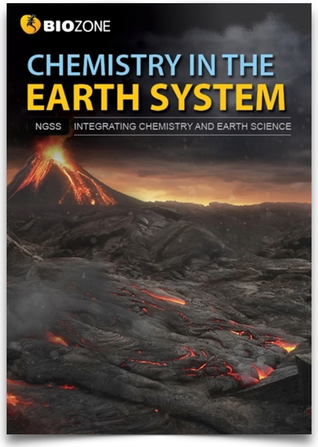
SCIENCE

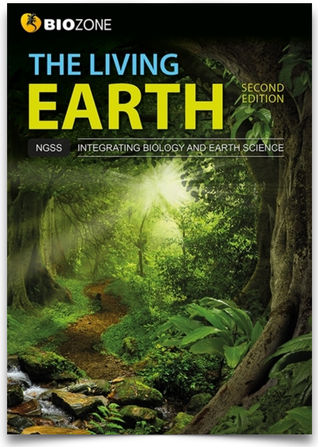
US PROGRAMS

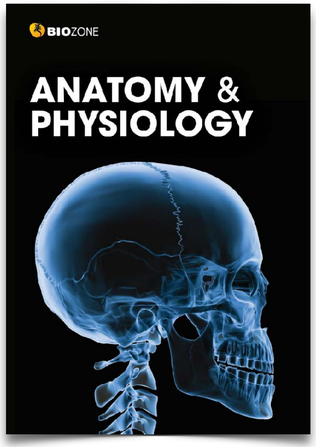


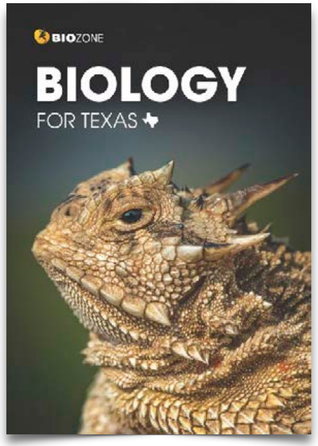


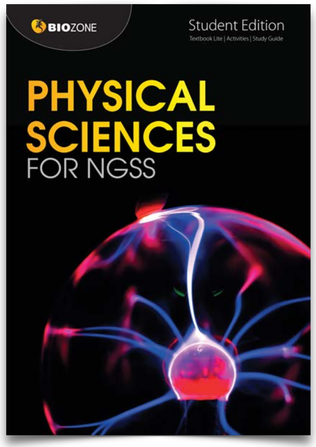


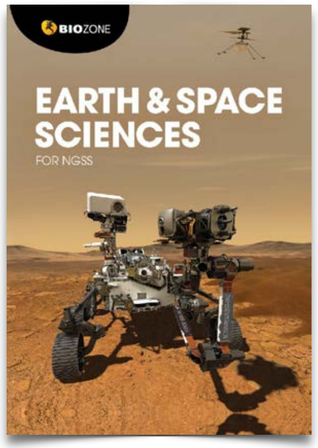


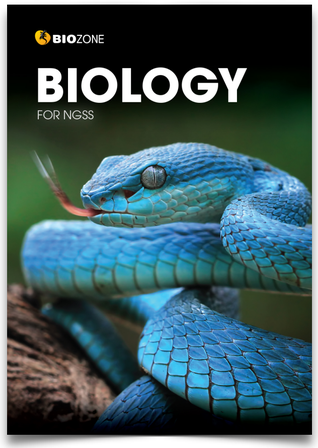


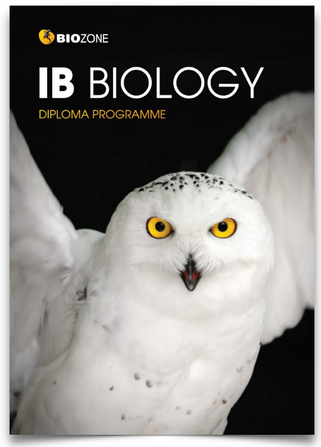


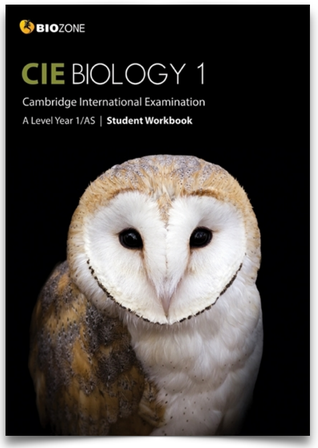


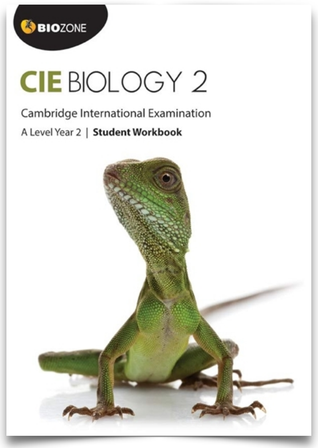




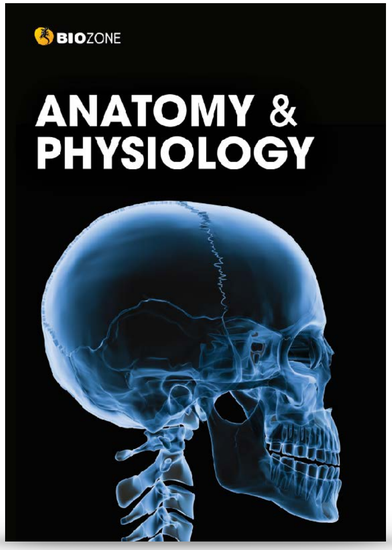


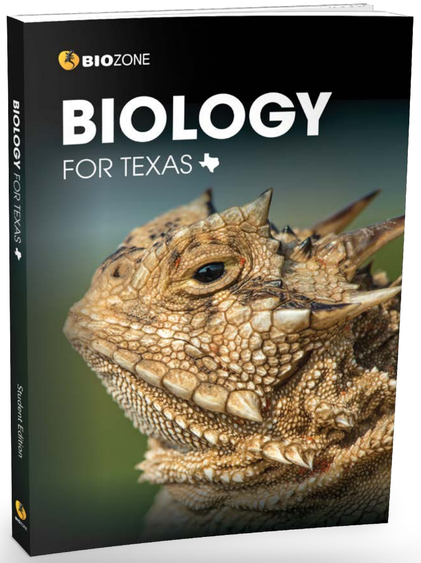


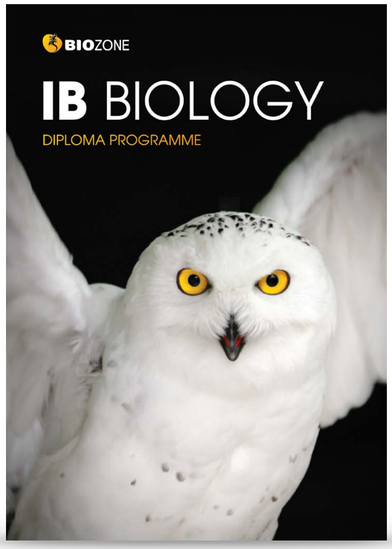


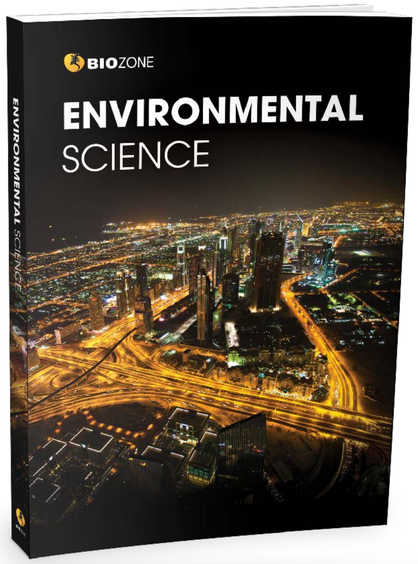


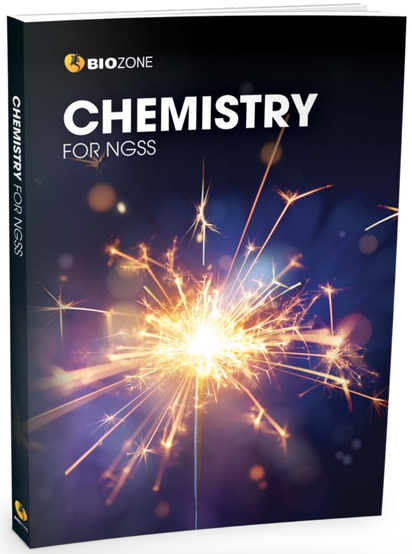
Recent & New Editions



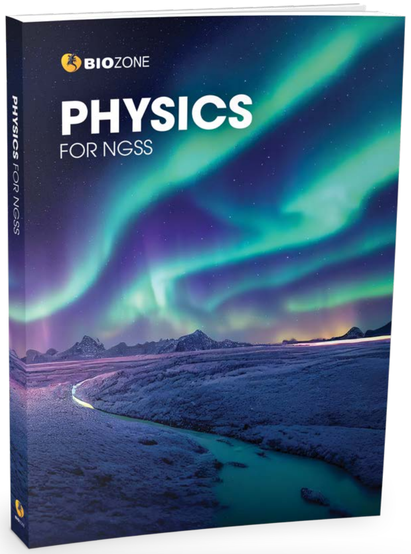








2025



2026

BIOZONE Worktexts

Combine the very best features of a **textbook** ....

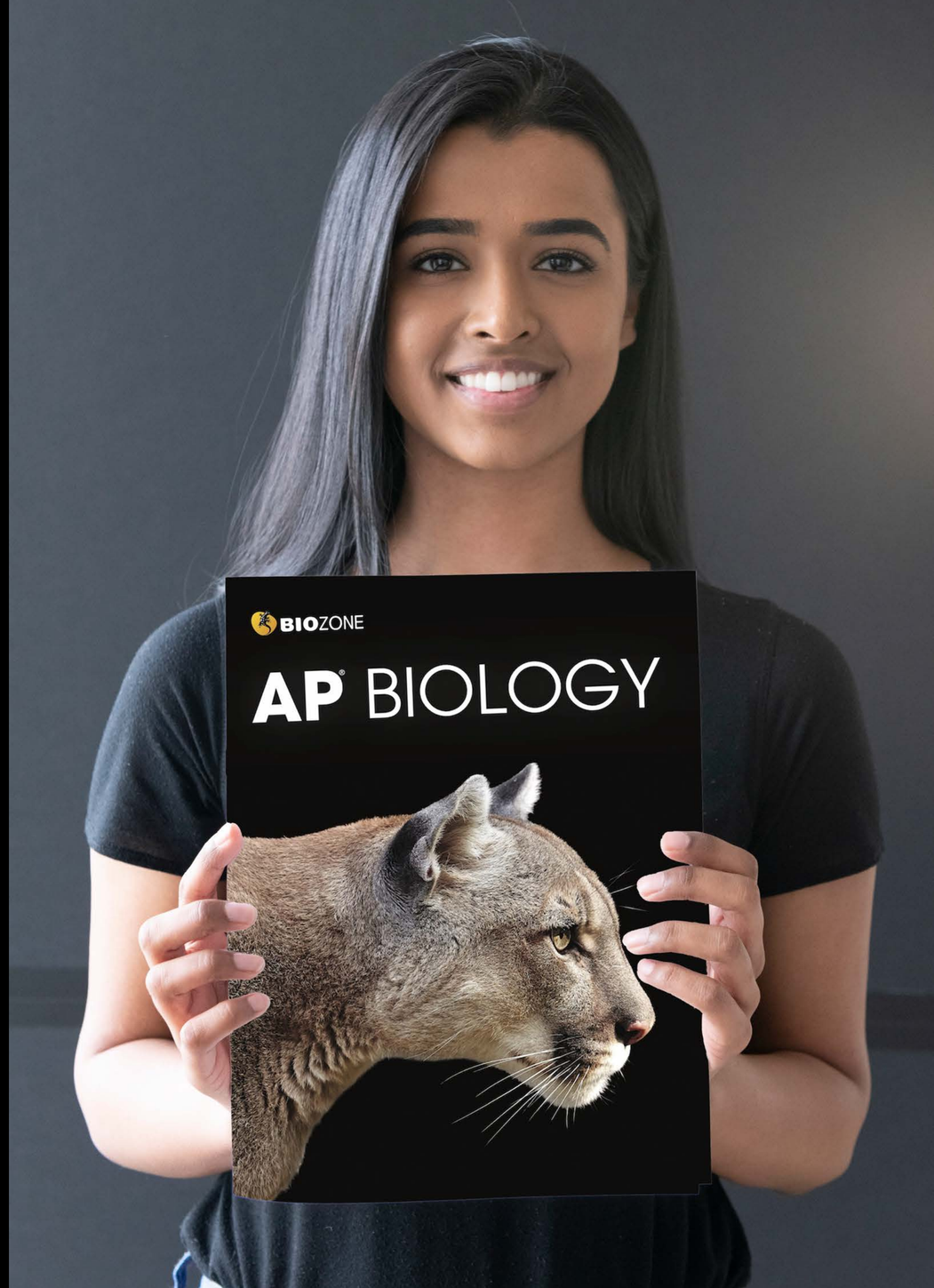
.... with the utility of **workbook**

Student-Owned **Worktext**

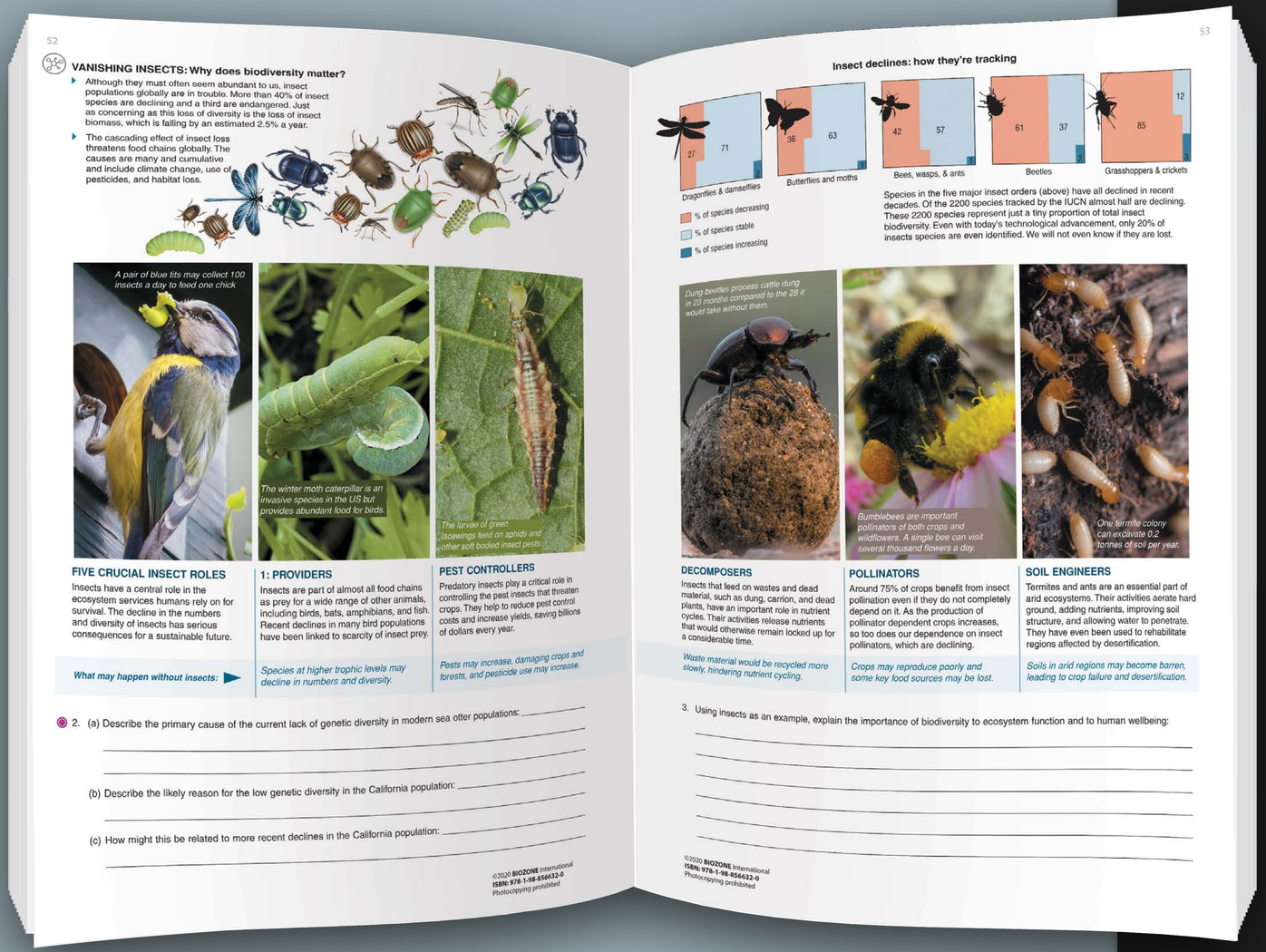
– *not* a traditional basal textbook

Our worktexts are designed to be consumable:

- **Combines** the *very best features* of a textbook with function and utility of a workbook
- Requires direct student interaction with content
- Students write answers directly onto the page that forms a **record of work**
- Engaging graphics with chunked text for accessibility
- Many data driven activities



What is the **BIOZONE solution?**



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VANISHING INSECTS: Why does biodiversity matter?

- Although they must often seem abundant to us, insect populations globally are in trouble. More than 40% of insect species are declining and a third are endangered. Just as concerning as this loss of diversity is the loss of insect biomass, which is falling by an estimated 2.5% a year.
- The cascading effect of insect loss threatens food chains globally. The causes are many and cumulative and include climate change, use of pesticides, and habitat loss.

A pair of blue tits may collect 100 insects a day to feed one chick

The winter moth caterpillar is an invasive species in the US but provides abundant food for birds.

The larvae of green lacewings feed on aphids and other soft bodied insect pests.

FIVE CRUCIAL INSECT ROLES

Insects have a central role in the ecosystem services humans rely on for survival. The decline in the numbers and diversity of insects has serious consequences for a sustainable future.

1: PROVIDERS

Insects are part of almost all food chains as prey for a wide range of other animals, including birds, bats, amphibians, and fish. Recent declines in many bird populations have been linked to scarcity of insect prey.

PEST CONTROLLERS

Predatory insects play a critical role in controlling the pest insects that threaten crops. They help to reduce pest control costs and increase yields, saving billions of dollars every year.

What may happen without insects:

Species at higher trophic levels may decline in numbers and diversity.

Pests may increase, damaging crops and forests, and pesticide use may increase.

2. (a) Describe the primary cause of the current lack of genetic diversity in modern sea otter populations: _____

(b) Describe the likely reason for the low genetic diversity in the California population: _____

(c) How might this be related to more recent declines in the California population: _____

ISBN: 978-1-98-856632-0

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Insect declines: how they're tracking

Species in the five major insect orders (above) have all declined in recent decades. Of the 2200 species tracked by the IUCN almost half are declining. These 2200 species represent just a tiny proportion of total insect biodiversity. Even with today's technological advancement, only 20% of insects species are even identified. We will not even know if they are lost.

Dung beetles process cattle dung in 23 months compared to the 28 it would take without them.

Bumblebees are important pollinators of both crops and wildflowers. A single bee can visit several thousand flowers a day.

One termite colony can excavate 0.2 tonnes of soil per year.

DECOMPOSERS

Insects that feed on wastes and dead material, such as dung, carrion, and dead plants, have an important role in nutrient cycles. Their activities release nutrients that would otherwise remain locked up for a considerable time.

POLLINATORS

Around 75% of crops benefit from insect pollination even if they do not completely depend on it. As the production of pollinator dependent crops increases, so too does our dependence on insect pollinators, which are declining.

SOIL ENGINEERS

Termites and ants are an essential part of arid ecosystems. Their activities aerate hard ground, adding nutrients, improving soil structure, and allowing water to penetrate. They have even been used to rehabilitate regions affected by desertification.

Waste material would be recycled more slowly, hindering nutrient cycling.

Crops may reproduce poorly and some key food sources may be lost.

Soils in arid regions may become barren, leading to crop failure and desertification.

3. Using insects as an example, explain the importance of biodiversity to ecosystem function and to human wellbeing: _____

ISBN: 978-1-98-856632-0

It is a unique *3-in-1 hybrid* resource:

- ☑ **Part textbook**
- ☑ **Part study guide**
- ☑ **Part activity workbook**

Supported by the

Teacher Toolkit

Professor John Hattie

Researcher | Professor | Author

Professor John Hattie is a researcher in education.

He holds a Ph.D. from the *University of Toronto, Canada*.

The design of BIOZONE's solution has been strongly influenced by the research published by Prof. Hattie.

His book: ***Visible Learning*** is a synthesis of more than 1,500 meta-studies over 90,000 studies involving more than 300 million students (the result of nearly 30 years of research about what works best for learning in schools).

Director of the **Melbourne Educational Research Institute** at the *University of Melbourne, Australia*, since March 2011.

Before, he was project director of **asTTle** and professor of education at the *University of Auckland, New Zealand*.

Visible Learning™ 250+ Influences on Student Achievement

STUDENT	ES
Prior knowledge and background	
Field independence	0.94
Non-standard dialect use	-0.29
Piagetian programs	1.28
Prior ability	0.98
Prior achievement	0.59
Relating creativity to achievement	0.35
Relating high school to university achievement	0.60
Relating high school achievement to career performance	0.38
Self-reported grades	1.33
Working memory strength	0.66
Beliefs, attitudes and dispositions	
Attitude to content domains	0.46
Concentration/persistence/ engagement	0.54
Grit/incremental vs. entity thinking	0.25
Mindfulness	0.28
Morning vs. evening	0.12
Perceived task value	0.46
Positive ethnic self-identity	0.12
Positive self-concept	0.47
Self-efficacy	0.71
Stereotype threat	-0.33
Student personality	0.30
Motivational approach, orientation	
Achieving motivation and approach	0.42
Boredom	-0.47
Deep motivation and approach	0.57
Depression	-0.26
Lack of stress	0.17
Mastery goals	0.06
Motivation	0.38
Performance goals	-0.01
Anxiety	-0.44
Surface motivation and approach	-0.14
Physical influences	
ADHD	-0.90
ADHD – treatment with drugs	0.32
Breastfeeding	0.04
Deafness	-0.61
Exercise/relaxation	0.21
Gender on achievement	0.08
Illness	-0.44
Lack of sleep	-0.05
Full compared to pre-term/low birth weight	0.57
Relative age within a class	0.45
Bullying	-0.20

CURRICULA	ES
Reading, writing and the arts	
Comprehensive instructional programs for teachers	0.72
Comprehension programs	0.55
Drama/arts programs	0.42
Exposure to reading	0.43
Music programs	0.30
Phonics instruction	0.60
Repeated reading programs	0.75
Reading Recovery	0.53
Sentence combining programs	0.15
Spelling programs	0.58
Visual-perception programs	0.55
Vocabulary programs	0.63
Whole language approach	0.06
Writing programs	0.46
Math and sciences	
Manipulative materials on math	0.30
Mathematics programs	0.59
Science programs	0.56
Use of calculators	0.27
Other curricula programs	
Bilingual programs	0.36
Career interventions	0.38
Chess instruction	0.34
Conceptual change programs	0.99
Creativity programs	0.64
Diversity courses	0.09
Extra-curricula programs	0.20
Integrated curricula programs	0.47
Juvenile delinquent programs	0.12
Motivation/character programs	0.35
Outdoor/adventure programs	0.43
Perceptual-motor programs	0.08
Play programs	0.50
Social skills programs	0.37
Tactile stimulation programs	0.58

HOME	ES
Family structure	
Adopted vs non-adopted care	0.25
Engaged vs disengaged fathers	0.21
Intact (two-parent) families	0.22
Other family structure	0.16
Home environment	
Corporal punishment in the home	-0.33
Early years' interventions	0.44
Home visiting	0.29
Moving between schools	-0.30
Parental autonomy support	0.12
Parental involvement	0.45
Parental military deployment	-0.16
Positive family/home dynamics	0.52
Television	-0.18
Family resources	
Family on welfare/state aid	-0.12
Non-immigrant background	0.01
Parental employment	0.03
Socio-economic status	0.52

SCHOOL	ES
Leadership	
Collective teacher efficacy	1.39
Principals/school leaders	0.37
School climate	0.43
School resourcing	
External accountability systems	0.20
Finances	0.21
Types of school	
Charter schools	0.04
Religious schools	0.24
Single-sex schools	0.08
Summer school	0.19
Summer vacation effect	0.02
School compositional effects	
College halls of residence	0.05
Desegregation	0.28
Diverse student body	0.10
Middle school interventions	0.18
Out-of-school curricula experiences	0.07
School choice programs	0.12
School size (600-900 students at secondary)	0.43
Other school factors	
Counseling effects	0.35
Modifying school calendars/ timetables	0.09
Pre-school programs	0.28
Suspension/expelling students	-0.20

The Visible Learning™ research synthesises findings from **1,600+** meta-analyses of **95,000+** studies involving **300** million students, into what works best in education.

Key for rating

- Potential to considerably accelerate student achievement
- Potential to accelerate student achievement
- Likely to have positive impact on student achievement
- Likely to have small positive impact on student achievement
- Likely to have a negative impact on student achievement

ES Effect size calculated using Cohen's *d*

CORWIN Visible Learning^plus

visiblelearningplus.com
corwin.com/visiblelearning

Visible Learning™ 250+ Influences on Student Achievement

CLASSROOM	ES
Classroom composition effects	
Detracking	0.09
Mainstreaming/inclusion	0.25
Multi-grade/age classes	0.04
Open vs. traditional classrooms	0.01
Reducing class size	0.15
Retention (holding students back)	-0.32
Small group learning	0.47
Tracking/streaming	0.12
Within class grouping	0.18
School curricula for gifted students	
Ability grouping for gifted students	0.30
Acceleration programs	0.68
Enrichment programs	0.48
Classroom influences	
Background music	0.10
Behavioral intervention programs	0.62
Classroom management	0.35
Cognitive behavioral programs	0.29
Decreasing disruptive behavior	0.34
Mentoring	0.12
Positive peer influences	0.53
Strong classroom cohesion	0.53
Students feeling disliked	-0.19

TEACHER	ES
Teacher attributes	
Average teacher effects	0.32
Teacher clarity	0.75
Teacher credibility	1.09
Teacher estimates of achievement	1.29
Teacher expectations	0.43
Teacher personality attributes	0.24
Teacher performance pay	0.05
Teacher verbal ability	0.22
Teacher-student interactions	
Student rating of quality of teaching	0.45
Teachers not labeling students	0.44
Teacher-student relationships	0.48
Teacher education	
Initial teacher training programs	0.10
Micro-teaching/video review of lessons	0.88
Professional development programs	0.37
Teacher subject matter knowledge	0.23

STUDENT LEARNING STRATEGIES	ES
Strategies emphasizing student meta-cognitive/ self-regulated learning	
Elaboration and organization	0.75
Elaborative interrogation	0.56
Evaluation and reflection	0.75
Meta-cognitive strategies	0.55
Help seeking	0.72
Self-regulation strategies	0.52
Self-verbalization and self-questioning	0.59
Strategy monitoring	0.58
Transfer strategies	0.86
Student-focused interventions	
Aptitude/treatment interactions	0.11
Individualized instruction	0.23
Matching style of learning	0.32
Student-centered teaching	0.36
Student control over learning	0.02
Strategies emphasizing student perspectives in learning	
Peer tutoring	0.51
Volunteer tutors	0.51
Learning strategies	
Deliberate practice	0.79
Effort	0.77
Imagery	0.51
Interleaved practice	0.47
Mnemonics	0.80
Note taking	0.51
Outlining and transforming	0.66
Practice testing	0.46
Record keeping	0.52
Rehearsal and memorization	0.73
Spaced vs. mass practice	0.65
Strategy to integrate with prior knowledge	0.93
Study skills	0.45
Summarization	0.74
Teaching test taking and coaching	0.30
Time on task	0.44
Underlining and highlighting	0.44

TEACHING STRATEGIES	ES
Strategies emphasizing learning intentions	
Appropriately challenging goals	0.59
Behavioral organizers	0.42
Clear goal intentions	0.51
Cognitive task analysis	1.29
Concept mapping	0.64
Goal commitment	0.40
Learning goals vs. no goals	0.51
Learning hierarchies-based approach	0.19
Planning and prediction	0.76
Setting standards for self-judgement	0.75
Strategies emphasizing success criteria	
Mastery learning	0.61
Worked examples	0.37
Strategies emphasizing feedback	
Classroom discussion	0.82
Different types of testing	0.12
Feedback	0.66
Formative evaluation	0.34
Questioning	0.48
Response to intervention	1.09
Teaching/instructional strategies	
Adjunct aids	0.35
Collaborative learning	0.34
Competitive vs. individualistic learning	0.24
Cooperative learning	0.40
Cooperative vs. competitive learning	0.53
Cooperative vs. individualistic learning	0.55
Direct instruction	0.59
Discovery-based teaching	0.21
Explicit teaching strategies	0.57
Humor	0.04
Inductive teaching	0.44
Inquiry-based teaching	0.46
Jigsaw method	1.20
Philosophy in schools	0.43
Problem-based learning	0.35
Problem-solving teaching	0.67
Reciprocal teaching	0.74
Scaffolding	0.58
Teaching communication skills and strategies	0.43

TECHNOLOGY, SCHOOL, & OUT-OF-SCHOOL STRATEGIES	ES
Implementations using technologies	
Clickers	0.22
Gaming/simulations	0.34
Information communications technology (ICT)	0.48
Intelligent tutoring systems	0.51
Interactive video methods	0.54
Mobile phones	0.43
One-on-one laptops	0.16
Online and digital tools	0.26
Programmed instruction	0.23
Technology in distance education	0.01
Technology in mathematics	0.33
Technology in other subjects	0.55
Technology in reading/literacy	0.29
Technology in science	0.23
Technology in small groups	0.21
Technology in writing	0.42
Technology with college students	0.42
Technology with elementary students	0.44
Technology with high school students	0.30
Technology with learning needs students	0.57
Use of PowerPoint	0.26
Visual/audio-visual methods	0.22
Web-based learning	0.33
Implementations using out-of-school learning	
After-school programs	0.40
Distance education	0.14
Home-school programs	0.16
Homework	0.29
Service learning	0.58
Implementations that emphasize school-wide teaching strategies	
Co- or team teaching	0.19
Interventions for students with learning needs	0.77
Student support programs – college	0.21
Teaching creative thinking	0.37
Whole-school improvement programs	0.28

Key for rating

- Potential to considerably accelerate student achievement
- Potential to accelerate student achievement
- Likely to have positive impact on student achievement
- Likely to have small positive impact on student achievement
- Likely to have a negative impact on student achievement

ES Effect size calculated using Cohen's *d*

The Visible Learning™ research synthesises findings from **1,600+** meta-analyses of **95,000+** studies involving **300** million students, into what works best in education.

CORWIN Visible Learning plus
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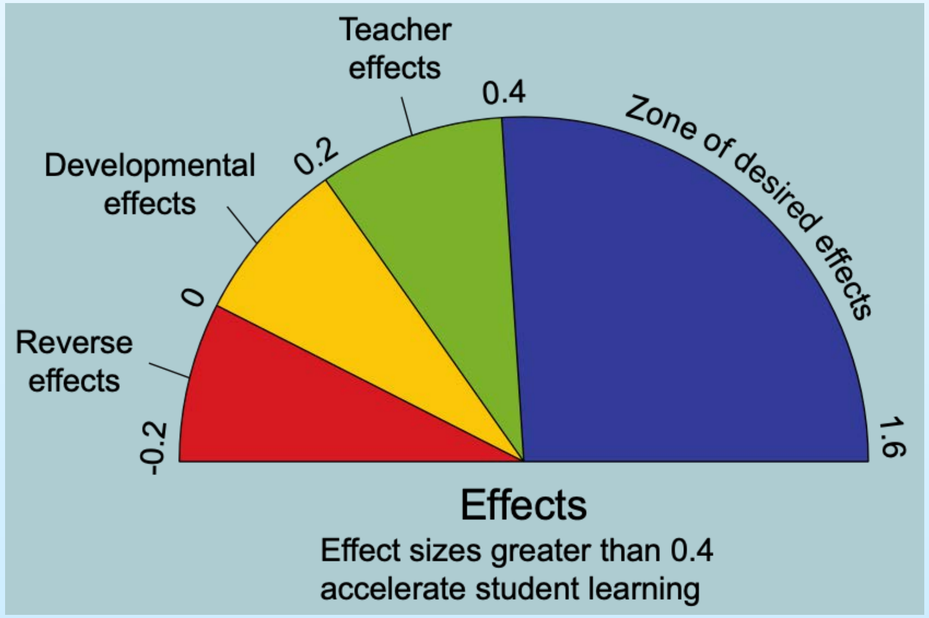
corwin.com/visiblelearning

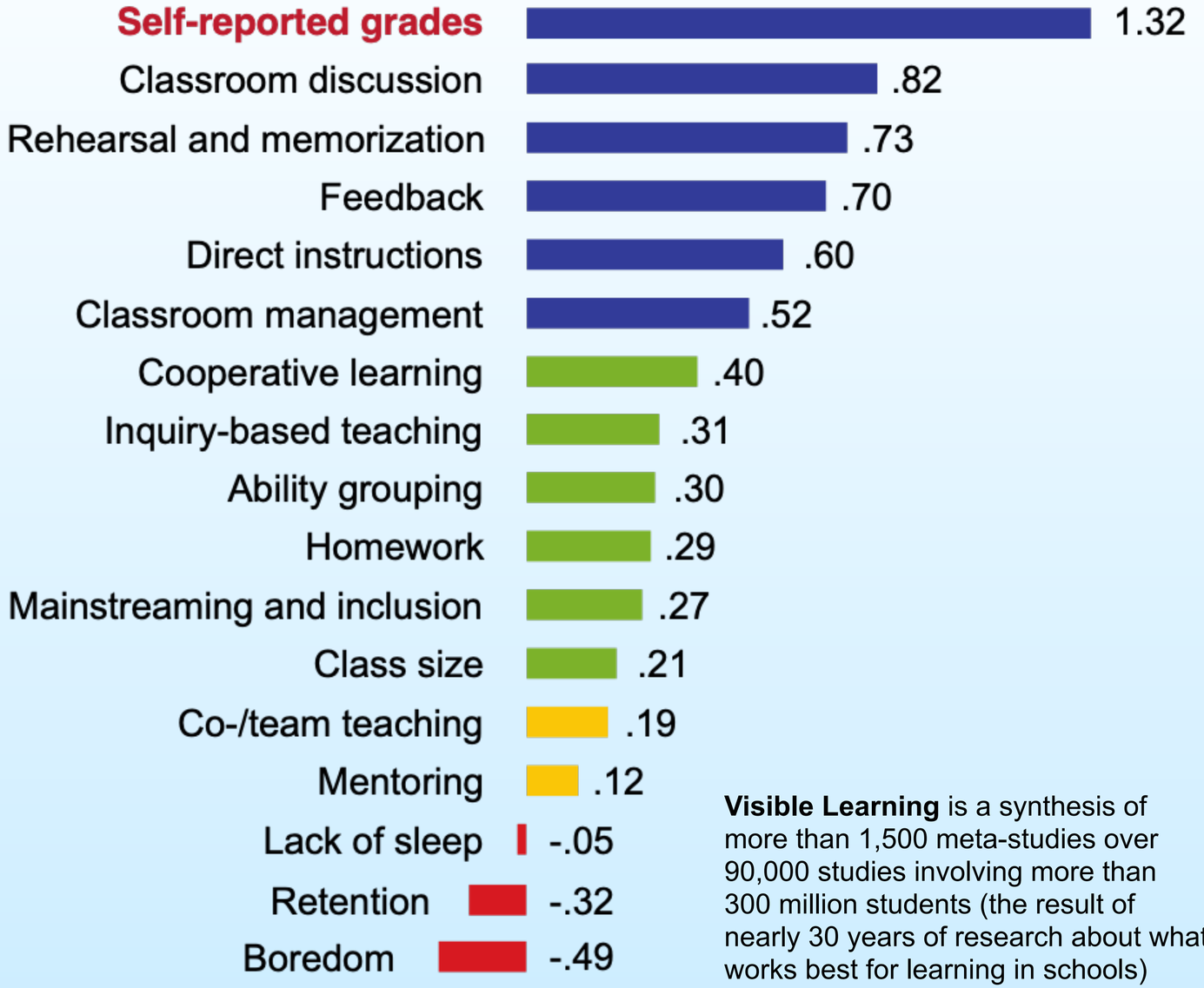
Self-Reported Grades

According to educational research, one of the most successful pedagogical tools leading to student academic achievement is **self-reported grades**.

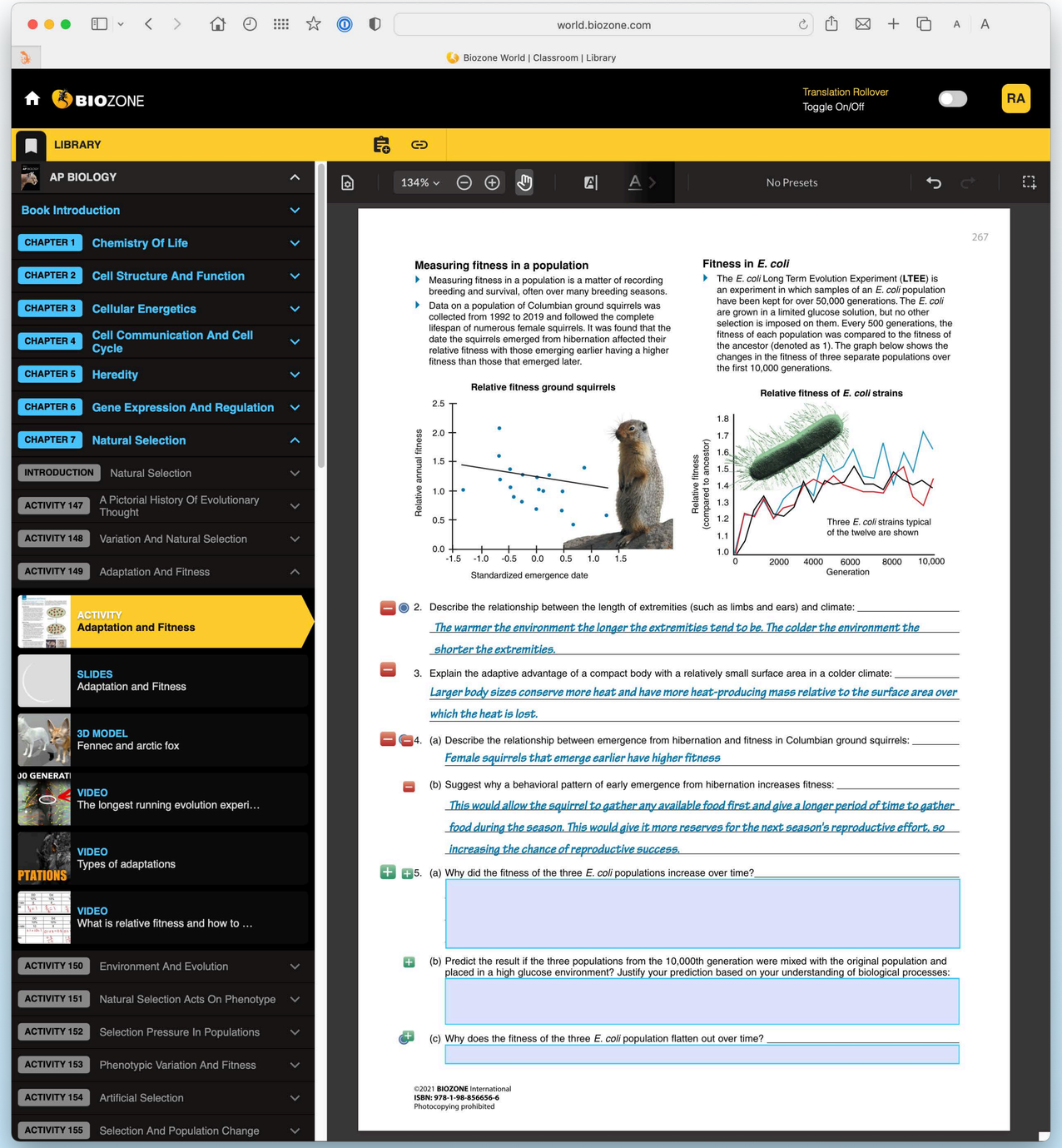
(Hattie, J. (2009) Visible Learning)



Influences on student achievement



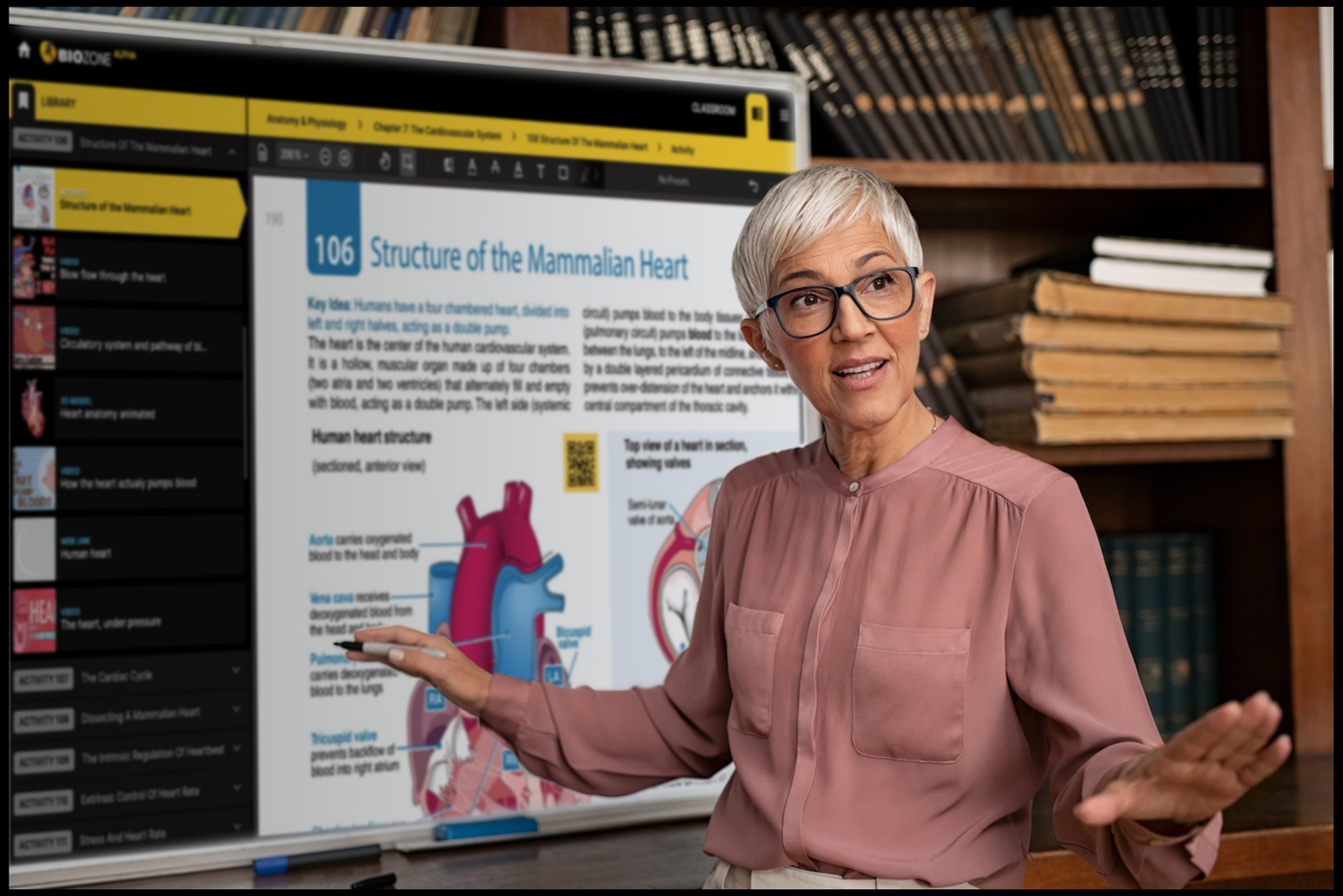
Visible Learning is a synthesis of more than 1,500 meta-studies over 90,000 studies involving more than 300 million students (the result of nearly 30 years of research about what works best for learning in schools)



How can students self-grade with BIOZONE?

- **Suggested answers** are provided via teacher access to **BIOZONE World**
- With *teacher guidance*, answers can be displayed to the class.
- Students can refine their own answers and strengthen their understanding.
- This provides a **powerful additional learning moment**.

Streamline classroom-based **Collaborative Learning**



Teacher
introduces Activity

Brief class discussion
to “unpack” the Activity’s
infographic or **data**

Breakout into small student groups

Student Group A
Discuss, then create consensus answers

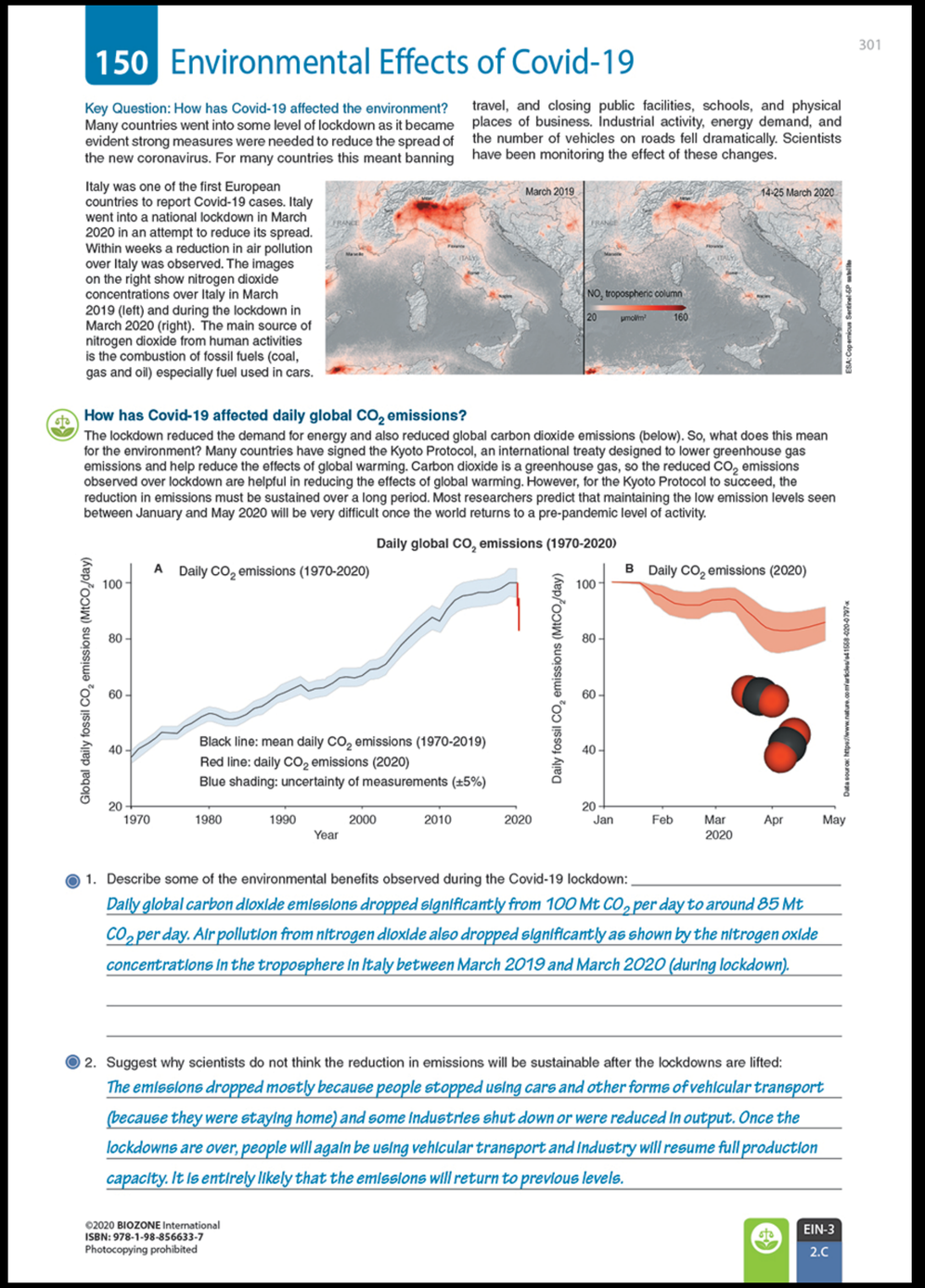
Student Group B
Discuss, then create consensus answers

Student Group C
Discuss, then create consensus answers

Students **quickly report back** via **teacher-led discussion** then **Self-grade** and **improve answers**

The Powerful 2nd Learning Moment

- Students write their **answers directly onto page** - thereby forming a **record of work**
- Having students **self-grade** their work, and possibly **correct** and **improve** their answers is a **powerful second learning moment**
- The **reference material**, questions and **answers** are all in one place - making for **easy revision**



301

150 Environmental Effects of Covid-19

Key Question: How has Covid-19 affected the environment?
Many countries went into some level of lockdown as it became evident strong measures were needed to reduce the spread of the new coronavirus. For many countries this meant banning travel, and closing public facilities, schools, and physical places of business. Industrial activity, energy demand, and the number of vehicles on roads fell dramatically. Scientists have been monitoring the effect of these changes.

Italy was one of the first European countries to report Covid-19 cases. Italy went into a national lockdown in March 2020 in an attempt to reduce its spread. Within weeks a reduction in air pollution over Italy was observed. The images on the right show nitrogen dioxide concentrations over Italy in March 2019 (left) and during the lockdown in March 2020 (right). The main source of nitrogen dioxide from human activities is the combustion of fossil fuels (coal, gas and oil) especially fuel used in cars.

How has Covid-19 affected daily global CO_2 emissions?

The lockdown reduced the demand for energy and also reduced global carbon dioxide emissions (below). So, what does this mean for the environment? Many countries have signed the Kyoto Protocol, an international treaty designed to lower greenhouse gas emissions and help reduce the effects of global warming. Carbon dioxide is a greenhouse gas, so the reduced CO_2 emissions observed over lockdown are helpful in reducing the effects of global warming. However, for the Kyoto Protocol to succeed, the reduction in emissions must be sustained over a long period. Most researchers predict that maintaining the low emission levels seen between January and May 2020 will be very difficult once the world returns to a pre-pandemic level of activity.

Daily global CO_2 emissions (1970-2020)

1. Describe some of the environmental benefits observed during the Covid-19 lockdown:
Daily global carbon dioxide emissions dropped significantly from 100 Mt CO_2 per day to around 85 Mt CO_2 per day. Air pollution from nitrogen dioxide also dropped significantly as shown by the nitrogen oxide concentrations in the troposphere in Italy between March 2019 and March 2020 (during lockdown).

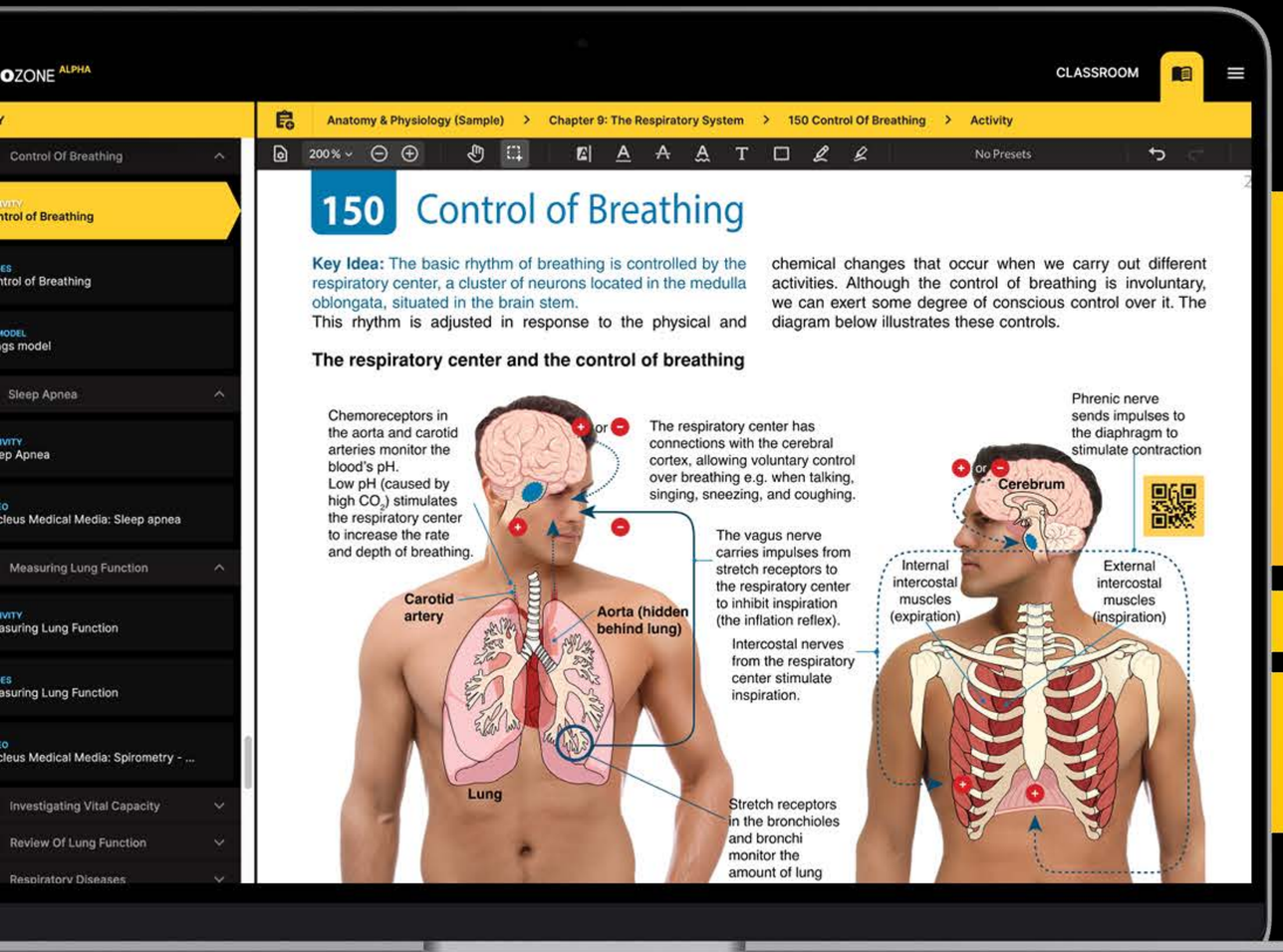
2. Suggest why scientists do not think the reduction in emissions will be sustainable after the lockdowns are lifted:
The emissions dropped mostly because people stopped using cars and other forms of vehicular transport (because they were staying home) and some industries shut down or were reduced in output. Once the lockdowns are over, people will again be using vehicular transport and industry will resume full production capacity. It is entirely likely that the emissions will return to previous levels.

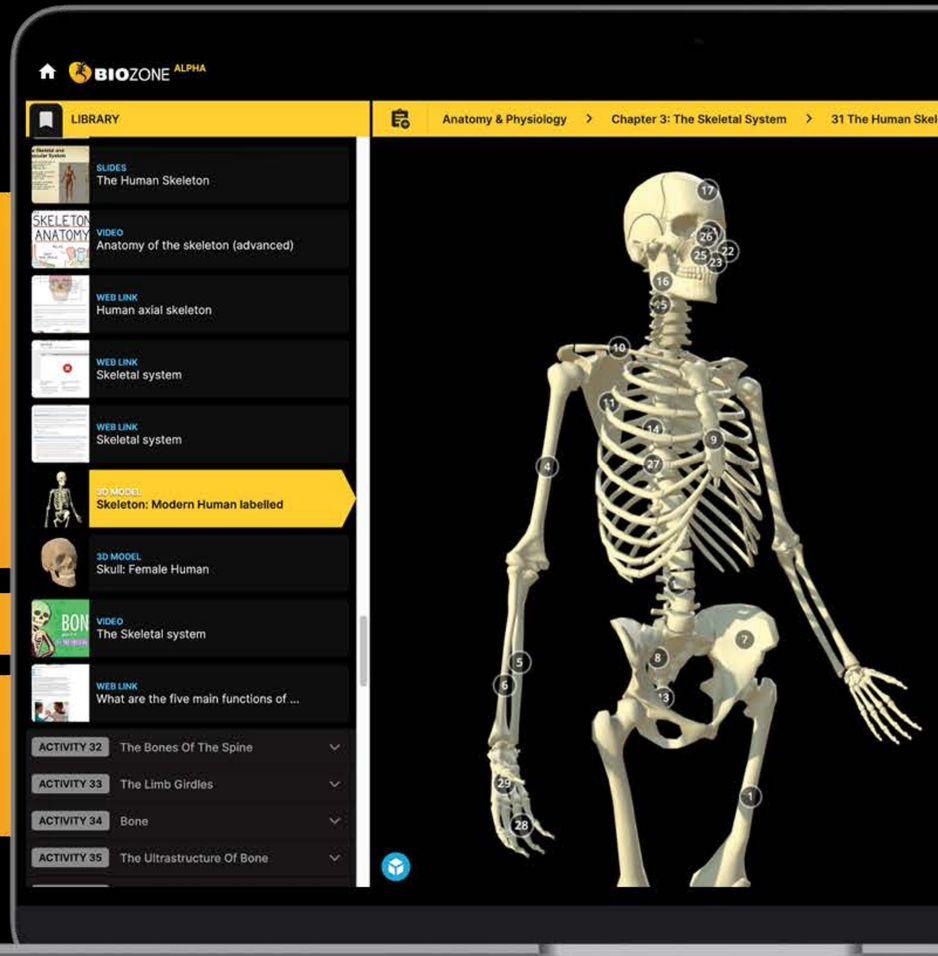
EIN-3
2.C


BIOZONE WORLD

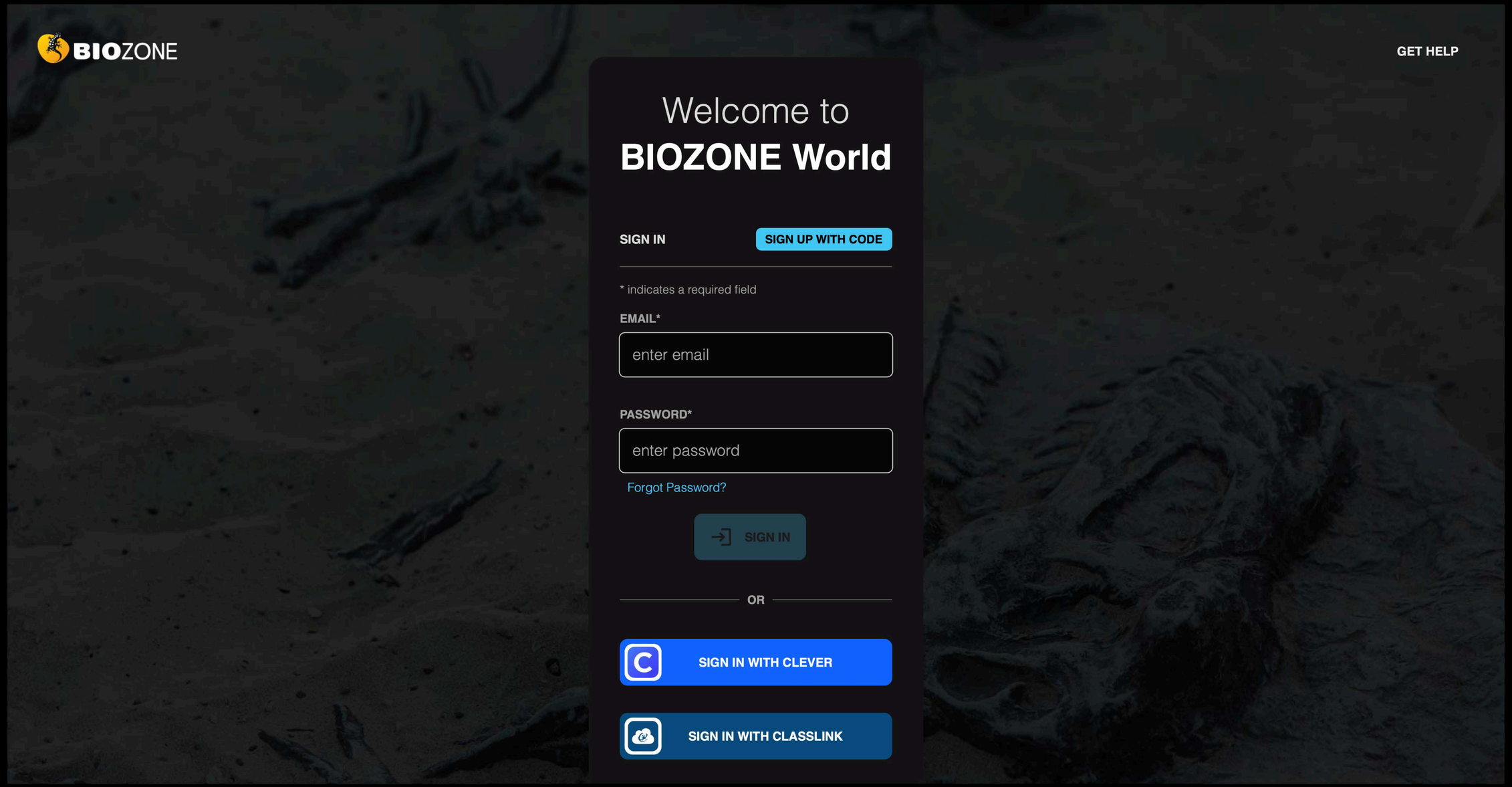
BIOZONE World

Brings together our rich collection of **digital resources**





world.biozone.com



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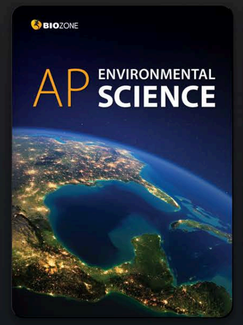
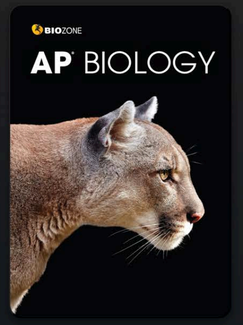
R ALLAN BIOLOGY

DASHBOARD ASSIGNMENTS STUDENTS

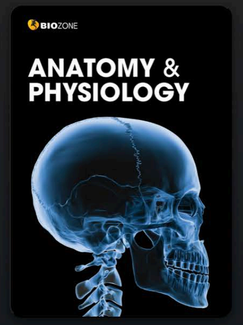
CLASS SETTINGS

ADVANCED PLACEMENT





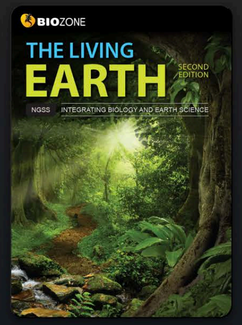
ANATOMY & PHYSIOLOGY



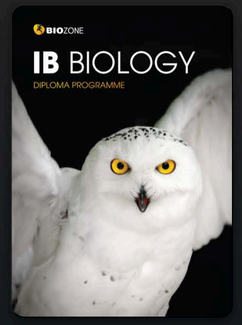
BIOLOGY FOR TEXAS

ENVIRONMENTAL SCIENCE

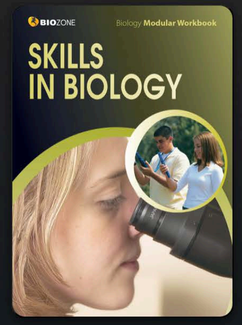
INTEGRATED NGSS - BIO



INTERNATIONAL BACCALAUREATE



MODULAR: SKILLS IN BIOLOGY

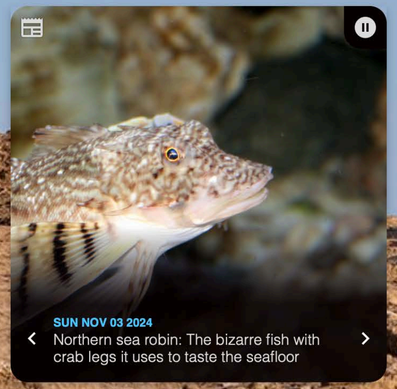


STANDARD NGSS - BIO

LAST ACTIVITY

ACTIVITY
Population Growth

REMINDERS



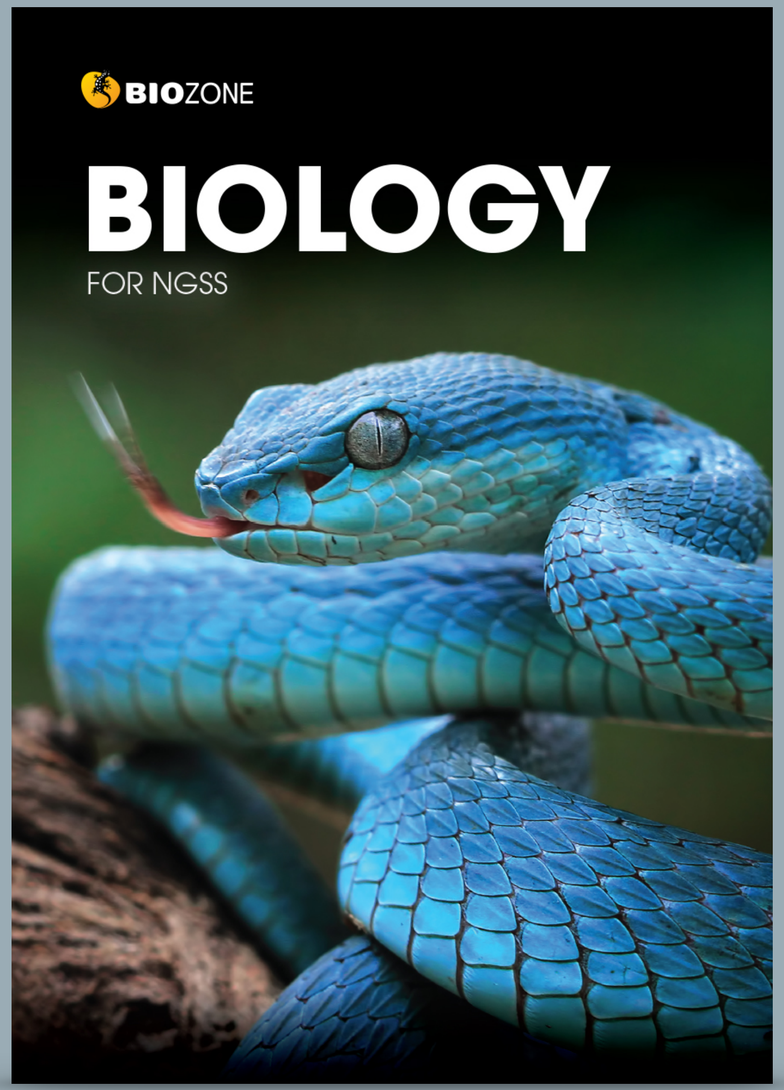
SUN NOV 03 2024
Northern sea robin: The bizarre fish with crab legs it uses to taste the seafloor

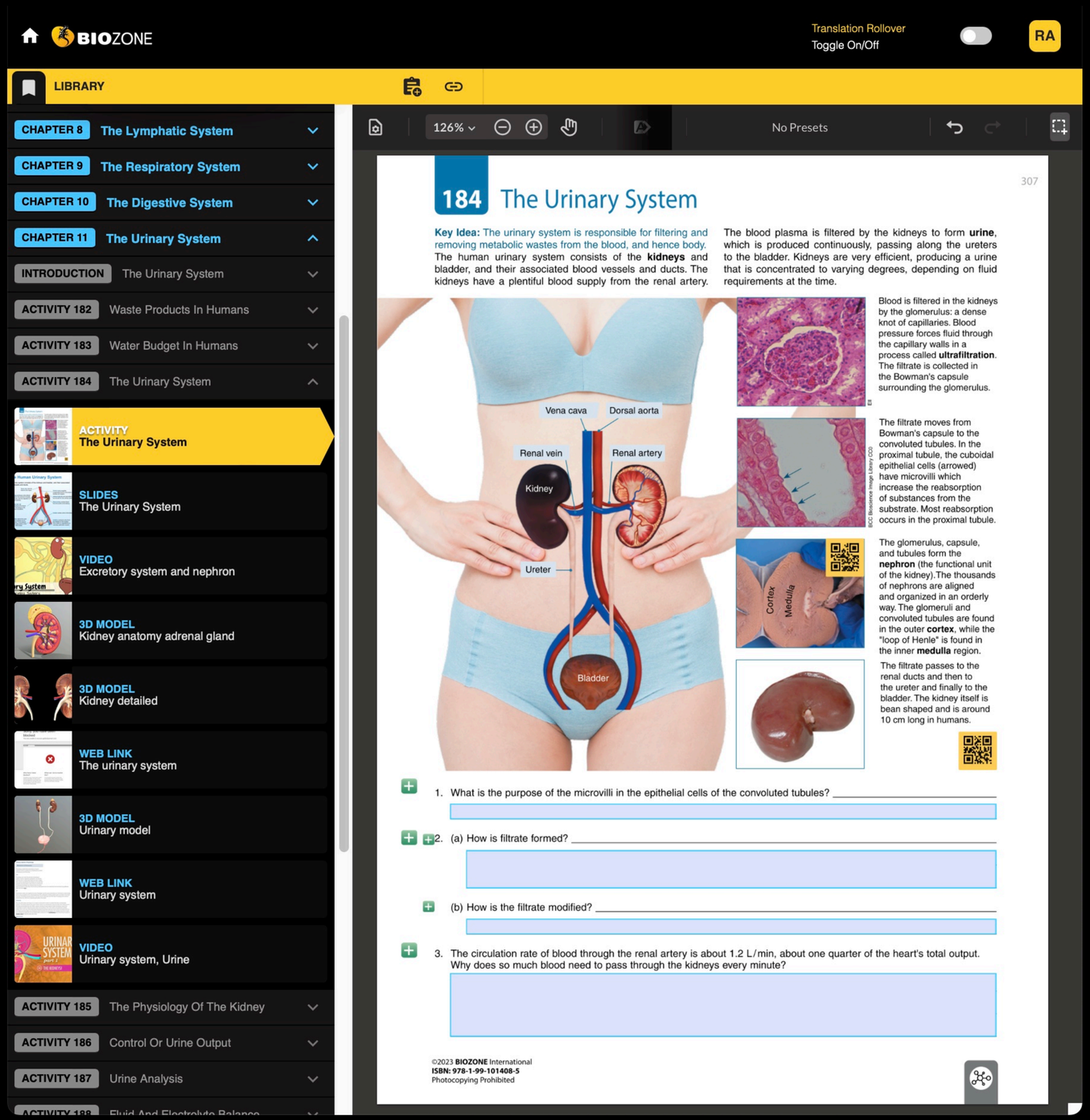
SAT NOV 30 2019
Natural Histories : Aye-Aye

Example: Biology for NGSS

In addition to a digital replica of the print book, BIOZONE World provides the following resources:

Presentation slides:	590
3D Models:	149
Intreractives:	79
PDF Downloads:	11
Curated OER Videos:	383
Web Links:	169





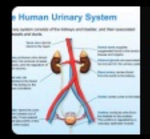
- Replicas of the printed books allow students to **answer questions online** ...

  ... this forms a "**Record of Work**" and may be graded by the teacher (if desired).

- Excellent *"interactives"* with direct access to BIOZONE's own **proprietary** resources:
  - **Presentation slides**
  - **3D models**

- Plus access to our **curated EOR** (Open Educational Resources) enrichment content:
  - **Curated Videos**
  - **Links to websites**

ACTIVITY
The Urinary System



SLIDES
The Urinary System

VIDEO
Excretory system and nephron

3D MODEL
Kidney anatomy adrenal gland

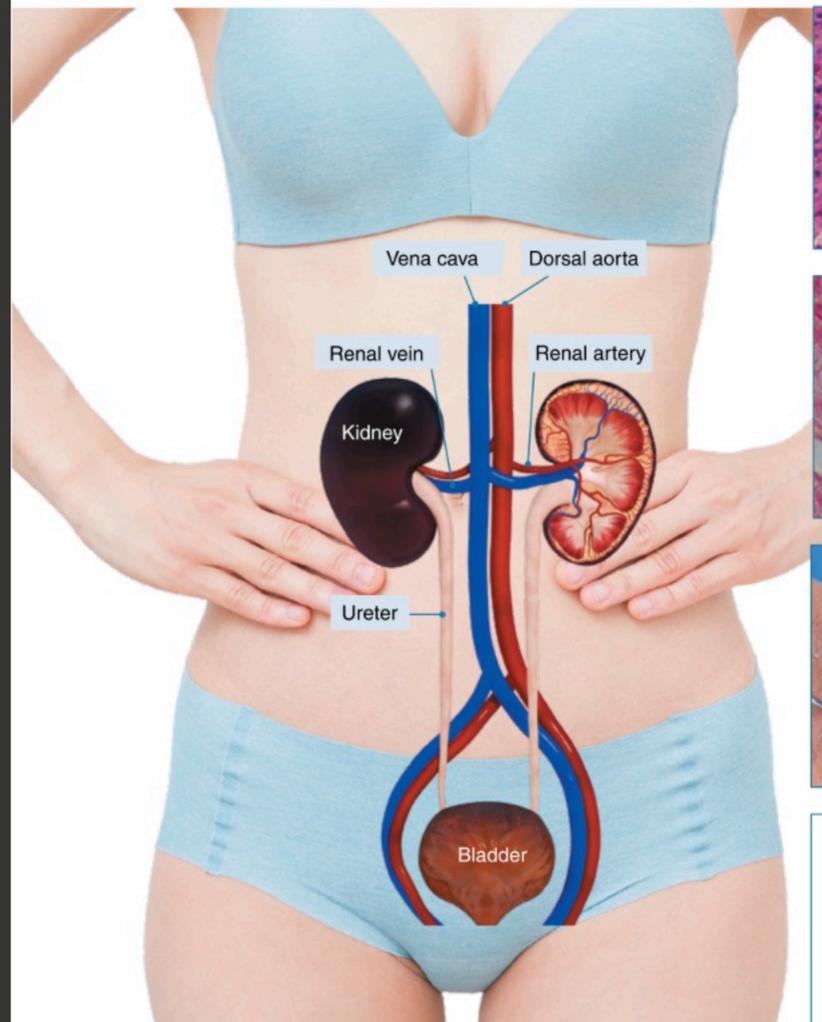
3D MODEL
Kidney detailed

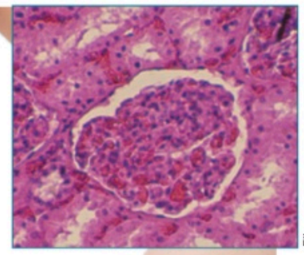
184 The Urinary System

Key Idea: The urinary system is responsible for filtering and removing metabolic wastes from the blood, and hence body.

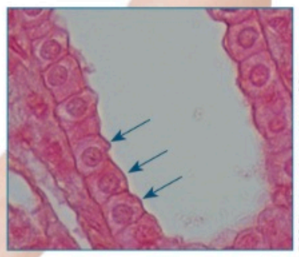
The human urinary system consists of the **kidneys** and bladder, and their associated blood vessels and ducts. The kidneys have a plentiful blood supply from the renal artery.

The blood plasma is filtered by the kidneys to form **urine**, which is produced continuously, passing along the ureters to the bladder. Kidneys are very efficient, producing a urine that is concentrated to varying degrees, depending on fluid requirements at the time.





Blood is filtered in the kidneys by the glomerulus: a dense knot of capillaries. Blood pressure forces fluid through the capillary walls in a process called **ultrafiltration**. The filtrate is collected in the Bowman's capsule surrounding the glomerulus.



BCC Bioscience Image Library CC0

The filtrate moves from Bowman's capsule to the convoluted tubules. In the proximal tubule, the cuboidal epithelial cells (arrowed) have microvilli which increase the reabsorption of substances from the substrate. Most reabsorption occurs in the proximal tubule.

The glomerulus, capsule, and tubules form the **nephron** (the functional unit of the kidney).The thousands of nephrons are aligned and organized in an orderly way. The glomeruli and convoluted tubules are found in the outer **cortex**, while the "loop of Henle" is found in the inner **medulla** region.

The filtrate passes to the renal ducts and then to the ureter and finally to the bladder. The kidney itself is bean shaped and is around 10 cm long in humans.

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LIBRARY

- CHAPTER 8 The Lymphatic System
- CHAPTER 9 The Respiratory System
- CHAPTER 10 The Digestive System
- CHAPTER 11 The Urinary System
  - INTRODUCTION The Urinary System
  - ACTIVITY 182 Waste Products In Humans
  - ACTIVITY 183 Water Budget In Humans
  - ACTIVITY 184 The Urinary System
    - ACTIVITY The Urinary System
    - SLIDES The Urinary System
    - VIDEO Excretory system and nephron
    - 3D MODEL Kidney anatomy adrenal gland
    - 3D MODEL Kidney detailed
    - WEB LINK The urinary system
    - 3D MODEL Urinary model
    - WEB LINK Urinary system
    - VIDEO Urinary system, Urine
  - ACTIVITY 185 The Physiology Of The Kidney
  - ACTIVITY 186 Control Or Urine Output
  - ACTIVITY 187 Urine Analysis
  - ACTIVITY 188 Fluid And Electrolyte Balance

126% No Presets

184 The Urinary System

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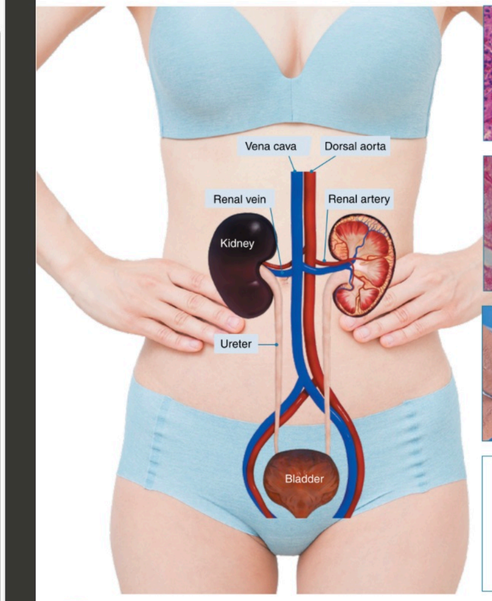
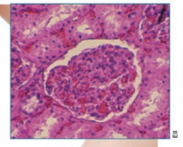
The human urinary system consists of the **kidneys** and bladder, and their associated blood vessels and ducts. The kidneys have a plentiful blood supply from the renal artery.

The blood plasma is filtered by the kidneys to form **urine**, which is produced continuously, passing along the ureters to the bladder. Kidneys are very efficient, producing a urine that is concentrated to varying degrees, depending on fluid requirements at the time.





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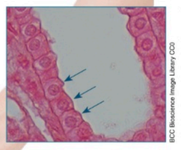

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The filtrate passes to the renal ducts and then to the ureter and finally to the bladder. The kidney itself is bean shaped and is around 10 cm long in humans.

1. What is the purpose of the microvilli in the epithelial cells of the convoluted tubules? _____

2. (a) How is filtrate formed? _____

   (b) How is the filtrate modified? _____

3. The circulation rate of blood through the renal artery is about 1.2 L/min, about one quarter of the heart's total output. Why does so much blood need to pass through the kidneys every minute?

ISBN: 978-1-99-101408-5

Digital replica of the print book, where the teacher can:

- **display model answers** at the click of a button ("+" and "–").
- View individual student answers for a single question with a "**Quick Review**" feature.
- Here is an activity that consists of a 5 page sequence on the Urinary System:

184 The Urinary System

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1. What is the purpose of the microvilli in the epithelial cells of the convoluted tubules?
The microvilli in the convoluted tubules increase the absorption of substances from the filtrate.

2. (a) How is filtrate formed? *Filtrate is formed when the blood is forced through the glomerulus at high pressure. This process is called ultrafiltration.*

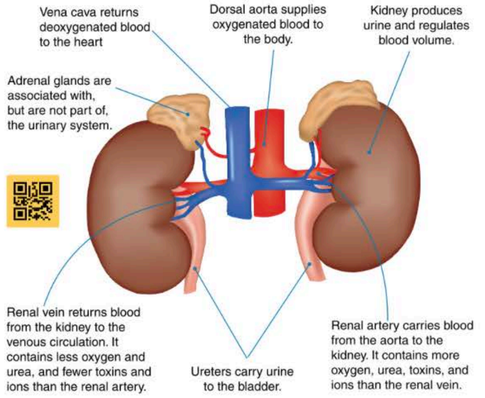
(b) How is the filtrate modified? *The filtrate is modified in the convoluted tubules where substances are removed from the filtrate (or added to it) as it passes through.*

3. The circulation rate of blood through the renal artery is about 1.2 L/min, about one quarter of the heart's total output. Why does so much blood need to pass through the kidneys every minute?
Large volumes of blood must pass through the kidneys so that metabolic wastes being transported from the body's cells can be removed from the blood before they accumulate.

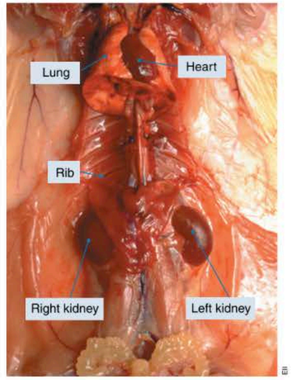
ISBN: 978-1-99-101408-5

The important roles of the kidneys in the urinary system

- The central organs of the urinary system in humans, and other mammals, are the kidneys. These are bean shaped organs that lie at the back of the abdominal cavity to either side of the spine (below right).
- The kidneys act as a selective filter of the blood, removing nitrogenous wastes (urea) and toxins and regulating blood composition and pH, while retaining useful substances, such as valuable ions and glucose. The kidneys receive blood under relatively high pressure via the arterioles from the renal artery. This relatively high pressure forces blood plasma out of the capillaries, forming a fluid called filtrate, which is then modified as it passes through the kidney to form the urine.
- Human kidneys (below left) are ~100-120 mm long and 25 mm thick. Each day they filter about 180 L of plasma. Most of this is reabsorbed, leaving a daily urine output of about 1 L.
- The kidneys help to maintain the body's internal chemical homeostasis, by adjusting the composition of the fluid excreted.



Kidneys *in-situ* (rat)



4. What are the important functions of the kidney? *Excrete nitrogenous wastes (as urea) and maintain water and solute balance and blood pH by selective removal and reabsorption of substances in the blood.*

5. Calculate the percentage of the plasma reabsorbed by the kidneys: *(179/180) x 100 = 99.4%*

6. The kidneys are located near the lower part of the rib cage. What do you think is the significance of this location?
The rib cage protects the kidneys from shock and damage by external forces.

7. A person can live more or less normally with just one kidney. What does this tell you about the kidneys?
It tells us a large part of the kidney is redundant, i.e. that is it is not required in order to maintain operation or function, or that there are very many more nephrons available than are actually required. A person can lose a kidney or the function of many nephrons (e.g. via disease) and still maintain healthy blood.

8. The functional unit of the kidney is a filter element called a nephron. There are at least 1 million nephrons in each kidney. If a person filters 180 L of plasma a day, approximately what volume of plasma does each nephron filter?

9. Describe the general passage of the blood through the kidney, and any changes to its composition:

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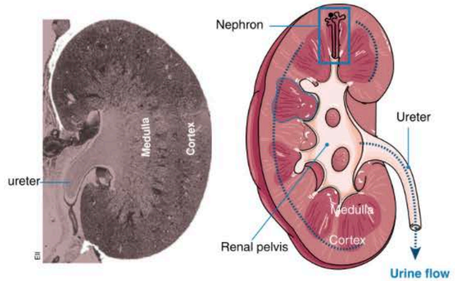
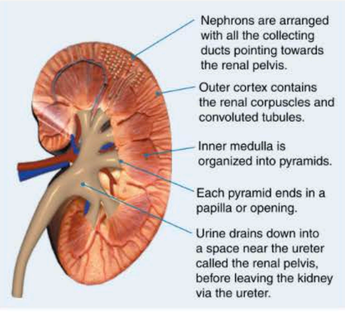
Internal structure of the human kidney

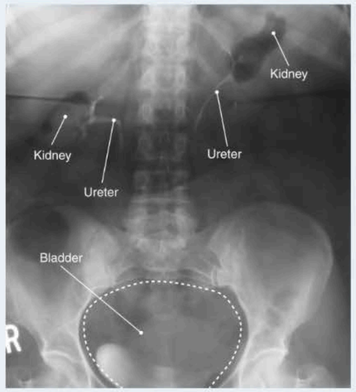




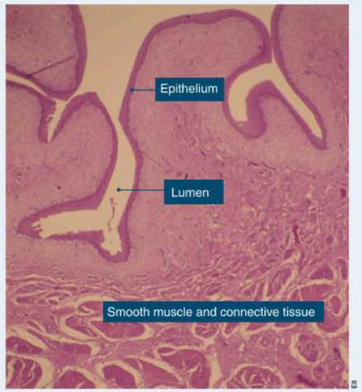
The outer cortex and inner medulla can be seen in a low power LM of the kidney. The ureter is seen extending into the fat and connective tissue surrounding and protecting the kidney.

The functional units of the kidney are selective filter elements called nephrons. Each kidney contains more than 1 million nephrons and they are precisely aligned so that urine is concentrated as it flows towards the ureter (model and diagram above). The alignment of the nephrons makes the kidney tissue appear striated (striped) and also makes it possible to fit in all the filtering units needed.

The bladder



The bladder is a hollow stretchable organ, which stores the urine before it leaves the body via the urethra. In this X-ray, it is empty and resembles a deflated balloon. The dotted line shows where it would sit if full.



The bladder is lined with transitional epithelium. This type of epithelium is layered, or stratified, so it can be stretched without the outer cells breaking apart from each other. This image shows the bladder in a deflated state.

10. Describe the location and orientation of the nephrons in a kidney: _____

11. Describe the structure and function of the bladder: _____

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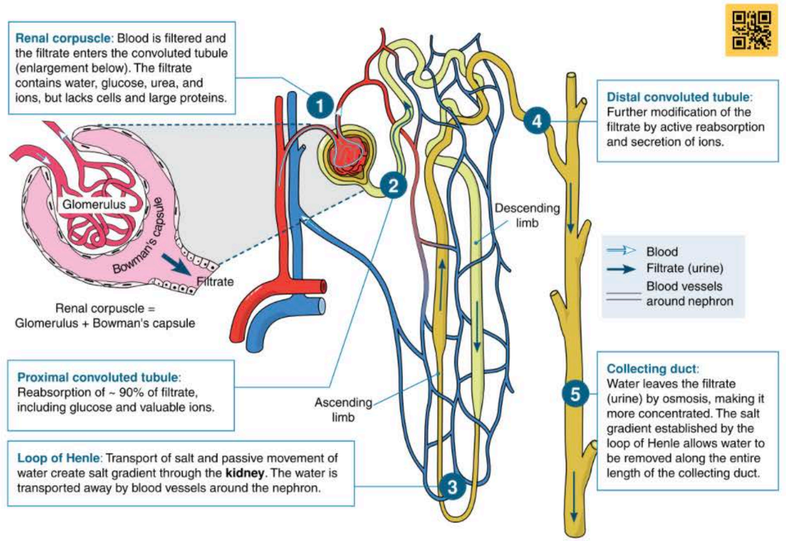
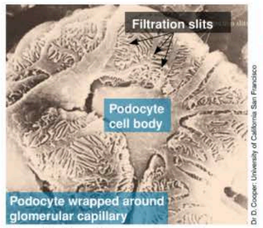
185 The Physiology of the Kidney

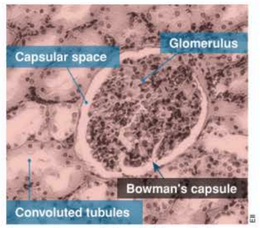
Key Idea: The functional unit of the kidney is the nephron. It is a selective filter element, comprising a renal corpuscle and its associated tubules and ducts.

Ultrafiltration, i.e. forcing fluid and dissolved substances through a membrane by pressure, occurs in the first part of the **nephron**, across the membranes of the capillaries and the glomerular capsule. The formation of the glomerular filtrate depends on the pressure of the blood entering the nephron (below). If it increases, filtration rate increases; when it falls, glomerular filtration rate also falls. This process is precisely regulated so that glomerular filtration rate per day stays constant. The initial filtrate, now called **urine**, is modified through secretion and tubular reabsorption, according to body's needs at the time.

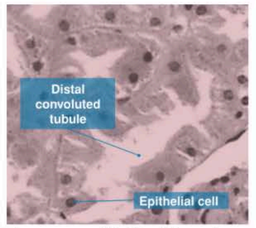




The epithelium of Bowman's capsule is made up of specialized cells called podocytes. The finger-like cellular processes of the podocytes wrap around the capillaries of the glomerulus, and the plasma filtrate passes through the filtration slits between them.



Bowman's capsule is a double walled cup, lying in the **cortex** of the kidney. It encloses a dense capillary network called the glomerulus. The capsule and its enclosed glomerulus form a renal corpuscle. In this section, the convoluted tubules can be seen surrounding the renal corpuscle.



There are around 16 different types of epithelial cells in the kidney, lining the surface of tubules, each with different functions. The kidney tissue also contains endothelial cells that line blood vessels, interstitial cells (in the space between functional cells), and immune cells.

1. Explain how water is reabsorbed in the kidneys? _____

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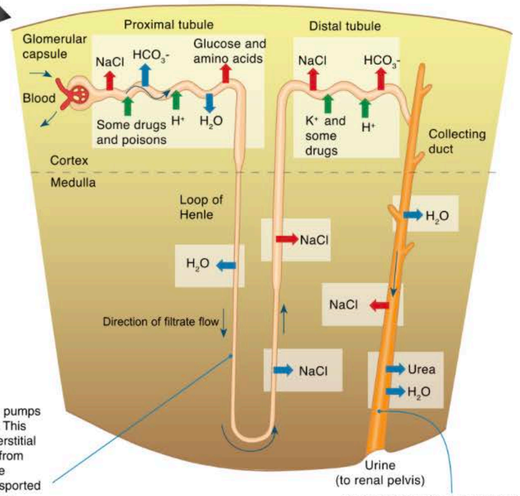
Summary of activities in the kidney nephron

Urine formation begins by ultrafiltration of the blood, as fluid is forced through the capillaries of the glomerulus, forming a filtrate similar to blood but lacking cells and proteins. The filtrate is then modified by secretion and reabsorption to add or remove substances, e.g. ions. The processes involved in urine formation are summarized below for each region of the nephron (glomerulus, proximal convoluted tubule, loop of Henle, and distal convoluted tubule), and the collecting duct. The loop of Henle acts as a countercurrent multiplier, establishing and increasing the salt gradient through the medullary region. This is possible because the descending loop is freely permeable to water but the ascending loop is not.



Filtrate
H_2O
Salts (NaCl, etc.)
HCO_3^- (bicarbonate)
H^+
Urea
Glucose; amino acids
Some drugs

Reabsorption
Active transport
Passive transport
Secretion
(active transport)

The thick ascending limb of the loop of Henle pumps out sodium and chloride ions from the filtrate. This produces a high solute concentrate in the interstitial space. This, in turn, draws water by osmosis from the descending limb of the loop Henle into the interstitial space. The water and ions are transported away by the capillaries. The countercurrent flow within the descending and ascending limbs multiplies the osmotic gradient between the tubular fluid and the interstitial space.

Reabsorption of a small amount of urea from the urine helps to maintain the osmotic gradient for the removal of water.

2. (a) What is the purpose of the salt gradient in the kidney? _____

(b) How is this salt gradient produced? _____

3. (a) Chronic dehydration, through either illness or environmental causes, can result in urine with a higher concentration of waste products and minerals. What are some possible conditions that could result from long term dehydration?

(b) Explain how these conditions could arise: _____

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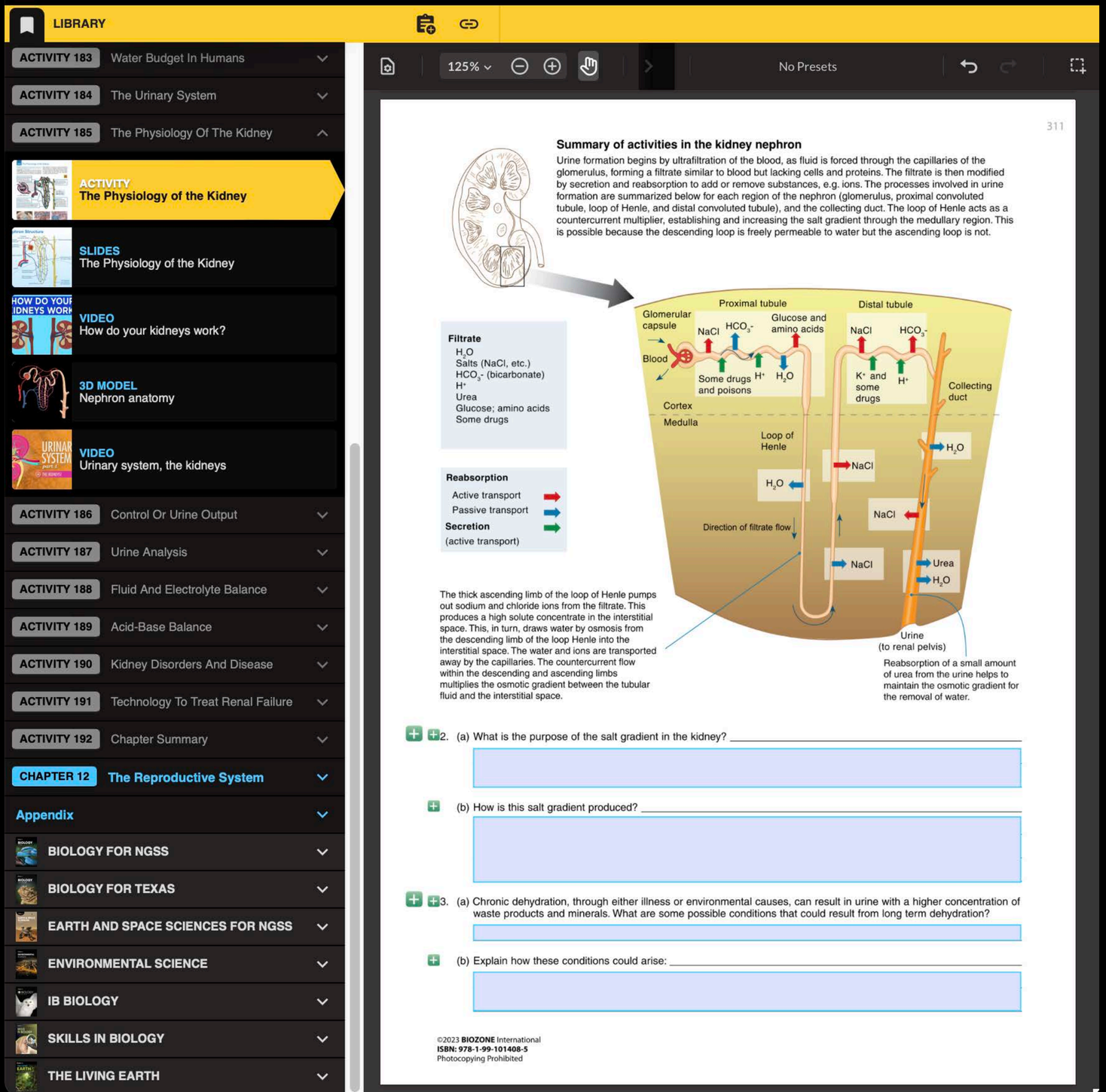

- Some questions have offline components (PDF file downloads).
- Students can add their own **additional notes**, **draw** on the page and **highlight** text passages.
- Teacher can **assign activities** to classes or individual students
  - A **resubmit** feature is available for a teacher to offer the student an opportunity to improve their answers

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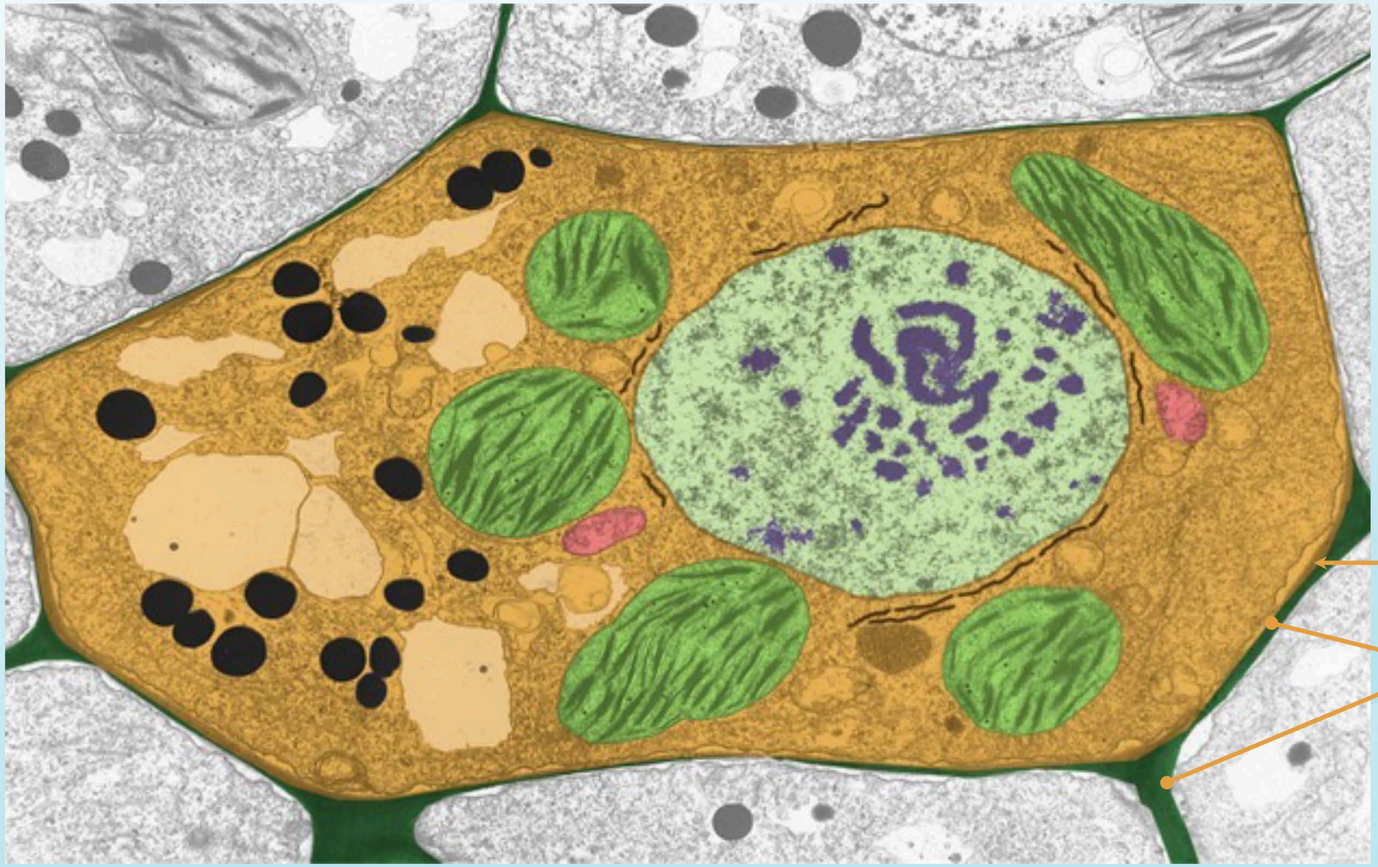
Plant Cells



Plant cells consist of a protoplast enclosed in a cellulose cell wall.

A protoplast is the name for all the cell contents within the plasma membrane, but does not include the cell wall.

The plant cell (left) clearly shows the cell wall coloured green, and brown line of the plasma membrane inside the cell wall.

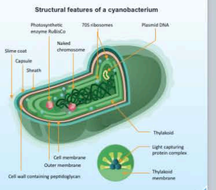
Prokaryotic Cells

Prokaryotic cells are small (~0.5-10 μm) single cells. They lack membrane-bound organelles.

They are relatively unstructured with little cellular organization.

- Their DNA, ribosomes, and enzymes are free floating within the cell's cytoplasm.
- The ribosomes (70S) are smaller than eukaryotic ribosomes.

They have a single, circular chromosome of naked DNA (not associated with protein). They commonly have small, circular accessory chromosomes called **plasmids**.



Prokaryotic Cells

Electron micrograph of a cluster of *E. coli* bacteria.

Photosynthetic bacteria have enzymes and light capturing membranes like those in eukaryotic chloroplasts.

Prokaryotes have cell walls, but they are different in composition to the cell walls of eukaryotes.

- Examples of bacterial cells include the gut bacterium *Escherichia coli* and the cyanobacterium *Anabaena*.

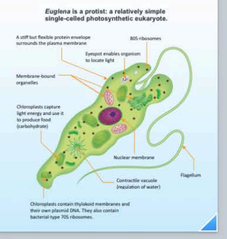
Eukaryotic Cells

Eukaryotic cells have a complex cell structure, with a high degree of organization including a membrane-bound nucleus and other membrane-bound organelles.

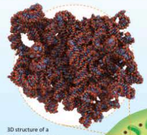
- Plant cells, animal cells, fungal cells, and protists are all eukaryotic cells.

Eukaryotic cells are large (30-150 μm).

They may exist as single cells or as part of a multicellular organism.



Eukaryotic Cells



3D structure of a eukaryotic ribosome

The genetic material of eukaryotic cells is found as multiple **linear chromosomes** consisting of DNA and associated proteins.

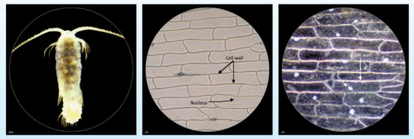
Ribosomes (80S) are larger than in prokaryotes, except those in mitochondria and chloroplasts, which are 70S.

Looking at Cells

The **microscope** is an important tool in biology for viewing cells and their features, which are far too small to be seen by the human eye.

- High power **compound light microscopes** use visible light and a combination of lenses to magnify objects up to several 100 times.
- **Electron microscopes** use beams of electrons and computer imaging to capture extremely fine detail of either surface or internal cellular features. They can magnify images up to 500,000 times.
- **Scanning Tunnelling Microscopes** have a resolution of 0.1 nm. They operate at the edge of the quantum realm and are able to image some

Looking at Cells



Dissecting microscopes are used for dissections, observing microbial cultures, and for identifying and sorting organisms, like this small crustacean.

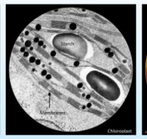
These onion epidermal cells are viewed with standard **bright field** lighting. Very little detail can be seen. The cell nuclei are barely visible.

Dark field illumination is excellent for viewing specimens that are almost transparent. The nuclei of these onion epidermal cells are clearly visible.

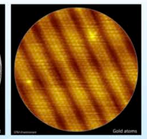
Looking at Cells

Leaf section

Scanning Electron Microscopes (SEMs) produce extremely high resolution images of the surface of cells and objects.



Transmission Electron Microscopes (TEMs) produce extremely high resolution images of the interior of cells and transparent objects.



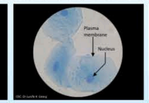
Scanning Tunnelling Microscopes (STMs) produce images based on current variation between an extremely fine needle and the object it moves over.

Staining

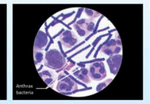
Some parts of the cell take up **stains** (chemical dyes) better than others. Stains can be used to highlight parts of the cell for better viewing with a microscope or they can improve contrast.

- A wide range of chemicals act as stains, including iodine and methylene blue.

Iodine is used to increase the contrast in transparent tissues, such as thin onion epidermis. Iodine stains are also used to show the presence of starch, binding starch to produce a blue-black color.



Methylene blue is a positively charged stain commonly used when viewing animal cells. It has a strong affinity for DNA (in the nucleus) and a weaker affinity for RNA (in the cytoplasm).



Some bacteria can be identified and viewed using **Gram staining**. Bacteria are classed as Gram positive and Gram negative depending on whether or not the stain is retained by the cell wall.

Magnification and Resolution

Magnification refers to the number of times larger an object appears compared to its actual size.

Paramecium (0.29 mm) at 200 x magnification

$$\text{Magnification} = \frac{\text{measured size of the object}}{\text{actual size of the object}}$$

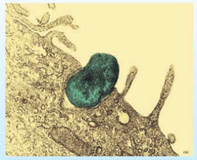
$$\text{Actual object size} = \frac{\text{size of the image}}{\text{magnification}}$$

Resolution is the ability to distinguish between close together but separate objects.

Resolution is a function of wavelength of light used to view the object.

Examples of high and low resolution for separating two objects viewed under the same magnification are given below.

Animal Cells



A phagocyte engulfing foreign material (blue) with its plasma membrane.

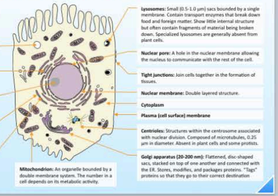
Eukaryotic cells have a similar basic structure, although they may vary tremendously in size, shape, and function.

Animal cells, unlike plant cells, do not have a regular shape.

- Plant cells are constrained by their rigid cell wall.
- However, many animal cells (such as **phagocytes**) are able to alter their shape for various purposes.

A Generalized Animal Cell

The structure and organelles of a **liver cell**, a relatively unspecialized human cell.



Vacuoles: Smaller than those in plant cells. Have minor roles in exocytosis and endocytosis.

Smooth endoplasmic reticulum: ER without ribosomes. A site for lipid and carbohydrate metabolism, including hormone synthesis.

Nucleolus: A dense, solid structure composed of crystalline protein and nucleic acid. Involved in ribosome synthesis.

Ribosomes: Small structures that make proteins. May float free in the cytoplasm or be attached to the surface of the rough endoplasmic reticulum.

Rough endoplasmic reticulum: A site of protein synthesis in both plant and animal cells. These have ribosomes attached to the surface. Synthesizes new membranes by adding proteins and phospholipids.

Mitochondrion: An organelle bounded by a double membrane system. The number in a cell depends on its metabolic activity.

Lysosomes: Small (0.5-1.0 μm) sacs bounded by a single membrane. Contain transport enzymes that break down food and foreign matter. Show little internal structure but often contain fragments of material being broken down. Specialized lysosomes are generally absent from plant cells.

Nuclear pore: A hole in the nuclear membrane allowing the nucleus to communicate with the rest of the cell.

Tight junctions: Join cells together in the formation of tissues.

Nuclear membrane: Double layered structure.

Cytoplasm

Plasma (cell surface) membrane

Centrioles: Structures within the centrosome associated with nuclear division. Composed of microtubules, 0.25 μm in diameter. Absent in plant cells and some protists.

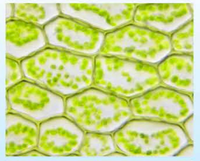
Golgi apparatus (20-200 nm): Flattened, disc-shaped sacs, stacked on top of one another and connected with the ER. Stores, modifies, and packages proteins. "Tags" proteins so that they go to their correct destination

Plant Cells

Certain features are common to almost all eukaryotic cells, including their three main regions: a **nucleus**, surrounded by a watery **cytoplasm**, which is itself enclosed by the **plasma membrane**.

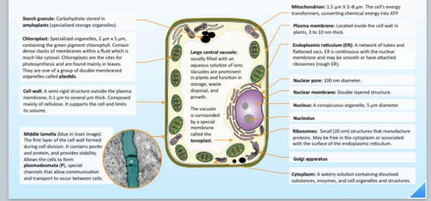
Plant cells are enclosed in a cellulose **cell wall**, which gives them a regular, uniform appearance.

- The cell wall protects the cell, maintains its shape, and prevents excessive water uptake. It provides rigidity to plant structures but permits the free passage of materials into and out of the cell.



Microscopic view of moss leaf (*Plagiomnium affine*).

A Generalized Plant Cell



Starch granule: Carbohydrate stored in **amyloplasts** (specialized storage organelles).

Chloroplast: Specialized organelles, 2 μm x 5 μm, containing the green pigment chlorophyll. Contain dense stacks of membranes within a fluid which is much like cytosol. Chloroplasts are the sites for photosynthesis and are found mainly in leaves. They are a type of double membraned organelles called **plastids**.

Cell wall: A semi-rigid structure outside the plasma membrane, 0.1 μm to several μm thick. Composed mainly of cellulose. It supports the cell and limits its volume.

Middle lamella (blue in inset image): The first layer of the cell wall formed during cell division. It contains pectin and protein, and provides stability. Allows the cells to form **plasmodesmata (P)**, special channels that allow communication and transport to occur between cells.

Large central vacuole: usually filled with an aqueous solution of ions. The vacuole is more prominent in plants and function in storage, waste disposal, and growth.

The vacuole is surrounded by a special membrane called the **tonoplast**.

Mitochondrion: 1.5 μm X 2–8 μm. The cell's energy transformers, converting chemical energy into ATP.

Plasma membrane: Located inside the cell wall in plants, 3 to 10 nm thick.

Endoplasmic reticulum (ER): A network of tubes and flattened sacs. ER is continuous with the nuclear membrane and may be smooth or have attached ribosomes (rough ER).

Nuclear pore: 100 nm diameter.

Nuclear membrane: Double layered structure.

Nucleus: A conspicuous organelle, 5 μm diameter.

Nucleolus

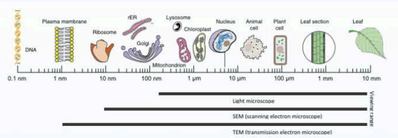
Ribosomes: Small (20 nm) structures that manufacture proteins. May be free in the cytoplasm or associated with the surface of the endoplasmic reticulum.

Golgi apparatus

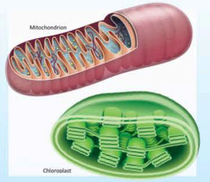
Cytoplasm: A watery solution containing dissolved substances, enzymes, and cell organelles and structures.

Cell Structures and Organelles

The log scale of measurements illustrates the relative sizes of some cellular structures.



Chloroplasts and Mitochondria



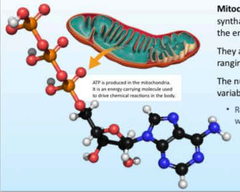
Chloroplasts and **mitochondria** are organelles involved in the production of energy storage molecules in cells.

Both are membranous organelles in which specialized biochemical reactions occur.

Chloroplasts are found only in plant cells and some protists.

Mitochondria are found in all eukaryotic cells.

Mitochondria



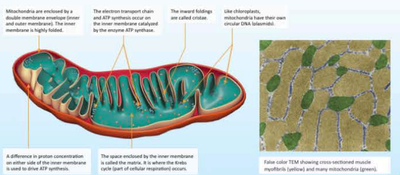
Mitochondria contain proteins (including ATP synthase) involved in the production of ATP, the energy storage molecule of cells.

They are much smaller than chloroplasts, ranging from about 0.75 to 3 μm.

The number of mitochondria in each cell is variable.

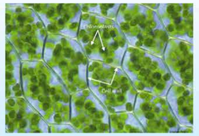
- Red blood cells have no mitochondria, whereas a heart cell can have up to 5000.

The Structure of a Mitochondrion



False color TEM showing cross-sectioned muscle myofibrils (yellow) and many mitochondria (green).

Chloroplasts



Chloroplasts visible in leaf cells. They appear green because they absorb blue and red light, reflecting green light. The chloroplasts are generally aligned so that their broad surface runs parallel to the cell wall to maximize the surface area available for light absorption.

Chloroplasts are the organelles responsible for photosynthesis.

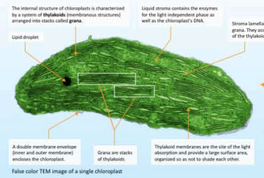
They have an internal structure characterized by a system of membranous structures called **thylakoids** with light-capturing pigments bound to the membranes.

- These absorb light of specific wavelengths, capturing light energy, which is then used to fix carbon into carbohydrates.

A mesophyll leaf cell contains between 50-100 chloroplasts.

The Structure of a Chloroplast

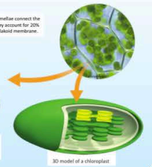
The internal structure of chloroplasts is characterized by a system of **thylakoids** (membranous structures) arranged into stacks called **grana**.



False color TEM image of a single chloroplast

Liquid stroma contains the enzymes for the light independent phase as well as the chloroplast's DNA.

Stroma lamellae connect the grana. They account for 20% of the thylakoid membrane.



3D model of a chloroplast

Cell Sizes

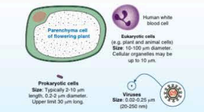
Different types of cells have different sizes.

Eukaryotic cells are much larger than prokaryotic cells, but even they vary widely in size.

Cells also have different shapes.

- Many have no fixed shape, but others have shapes approximating spheres (e.g. *Streptococcus*), cylinders (e.g. *E. coli*), or rectangular prisms (e.g. plant cells).

The volume of these cells can then be estimated using the appropriate formula for their shape.

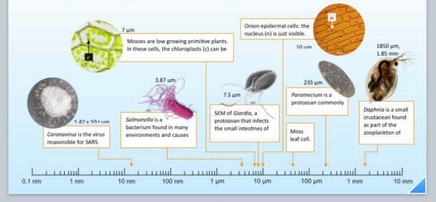


Unit of length (international system)

Unit	Meters	Equivalent
1 meter (m)	1 m	= 1000 millimeters
1 millimeter (mm)	10^{-3} m	= 1000 micrometers
1 micrometer (μm)	10^{-6} m	= 1000 nanometers
1 nanometer (nm)	10^{-9} m	= 1000 picometers

Micrometers are sometimes referred to as microns. Smaller structures are usually measured in nanometers (nm) e.g. molecules (1 nm) and plasma membrane thickness (10 nm).

Comparing Microscopic Measurements

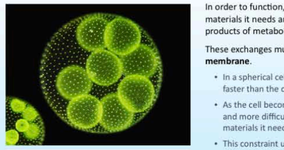


Volume of Three Dimensional Shapes

When looking at cells or cellular structures, it is important to understand how the size and shape of the cell affects its relative **volume** and **surface area**.

	Sphere	Cube	Rectangular prism	Cylinder
Biological example	Staphylococcus bacterial cell	Kidney tubule cell	Intestinal epithelial cell	Axon of neuron
Surface area: The sum of all areas of all shapes covering an object's surface.	$4\pi r^2$	$6w^2$	$2(lh + lw + hw)$	$(2\pi r^2) + (2\pi rh)$
Volume: The amount that a 3-dimensional shape can hold.	$\frac{4}{3}\pi r^3$	w^3	lwh	$\pi r^2 h$

Limitations to Cell Size



The size of spherical cells (such as this Volvox colony) is limited by the rate of diffusion. To become larger, cells must become a different shape (such as long and thin, like nerve cells, or flattened, like red blood cells).

In order to function, a cell must obtain the raw materials it needs and dispose of the waste products of metabolism.

These exchanges must occur across the **plasma membrane**.

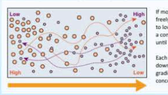
- In a spherical cell, the cell volume increases faster than the corresponding surface area.
- As the cell becomes larger, it becomes more and more difficult for it to obtain all the materials it needs to sustain its metabolism.
- This constraint ultimately limits the size of the cell.

Diffusion

Diffusion is the movement of particles down a concentration gradient.

- It is a **passive process**, meaning it needs no input of energy to occur.

During diffusion, molecules move randomly about, eventually becoming evenly dispersed.



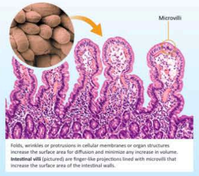
If molecules can move freely, they move from high to low concentration (down a concentration gradient) until evenly dispersed.

Each molecule moves down its own concentration gradient independent of the concentration gradients of

Factors affecting the rate of diffusion

Concentration gradient	The rate of diffusion is higher when there is a greater difference between the concentrations of two regions.
The distance moved	Diffusion over shorter distance occurs at a greater rate than over a larger distance.
The surface area involved	The larger the area across which diffusion occurs, the greater the rate of diffusion.
Barriers to diffusion	Thick barriers have a slower rate of diffusion than thin barriers.
Temperature	Particles at a high temperature diffuse at a greater rate than at a low temperature.
Solubility	Lipid-soluble or non-polar molecules pass across membranes more easily than polar materials, so their rates of diffusion are faster.
Solvent density	As the density of a solvent increases, the rate of diffusion decreases. Cellular dehydration adversely affects diffusion rates within cells.

The Effect of Increasing Size



Folds, wrinkles or protrusions in cellular membranes or organ structures increase the surface area for diffusion and minimize any increase in volume. **Intestinal villi** (pictured) are finger-like projections lined with microvilli that increase the surface area of the intestinal walls.

The transport of substances across membranes allows cells to exchange matter with their environment.

Simple diffusion and **active transport** involving membrane proteins are both affected by cell size and shape.

- This is because these things affect the amount of **surface area** available relative to the cell's **volume**.

The larger a cell is, the more raw materials it needs and the further molecules need to move to reach their destination within the cell.

The Effect of Increasing Size

A cell's **surface area** is important in determining how many molecules it can obtain.

Its **volume** is important in determining how quickly molecules can reach certain parts of the cell.

Surface area to volume ratio is therefore crucial to cell function.

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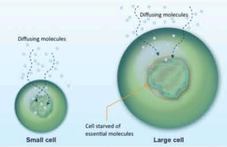
Cellular Supply and Demand



The size and shape of a cell reflects its function and the need for essential molecules to move in and out.

- The greater the spherical diameter of a cell, the more material it contains and the further molecules have to move in order to reach the center.
- At the same time, its **metabolic requirements** for raw materials increase.

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Cellular Supply and Demand

The problem of supply and demand can be solved by **reducing** the diameter of the cell along one axis or **elongating** it along another.

- An elongated sphere or cylinder (e.g. a rod shaped cell) has a greater surface area than a sphere of the same volume.

In this way, a cell can grow larger while still gaining the materials it needs.

The cells of multicellular organisms are often highly specialized to maximize SA: V.

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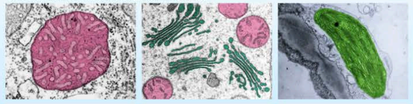
Organelles in Cells

Compartmentalizing within the cell also helps with issues of size.

Specialized **organelles** can concentrate the reactants they require and so are able to carry out reactions more easily and with greater efficiency.



Aerobic cellular respiration occurs within **mitochondria**, which themselves have specific regions in which different phases occur. A large area of internal membrane is important.

The membrane-bound compartments of the **Golgi** (green) are responsible for modifying and packaging proteins for secretion. These events are localized for greater efficiency.

Chloroplasts in plant cells isolate the reactions of photosynthesis from the rest of the cell. Compartments within the chloroplast further isolate the different reaction phases.

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Looking at Cellular Transport

As an object becomes larger, its **surface area to volume ratio** decreases and diffusion becomes a less effective way to transport materials to the inside.

This affects the ability of a cell to make efficient exchanges with the environment.

The effectiveness of diffusion is the **controlling factor** determining how big an individual cell can become.

In single-celled organism diffusion is much more effective and the cell's requirements are easily met. In a larger multicellular organism, specialized body systems are needed to transport materials to and from cells and tissues.

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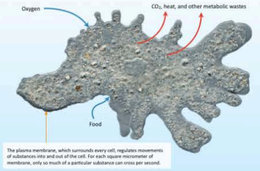
Single-Celled Organisms



Single-celled organisms (e.g. *Amoeba*), are small and have a large surface area relative to the cell's volume.

The cell's requirements can be met by the diffusion or active transport of materials into and out of the cell.

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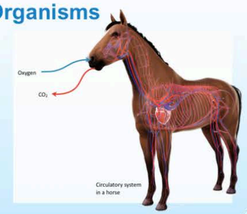
Multicellular Organisms

Large **multicellular organisms** (e.g. plants and animals) generally have a small surface area compared to their volume.

They require specialized body systems to transport the materials they need to and from the cells and tissues in their body.

In most multicellular organisms, even small ones such as insects, a specialized **gas exchange** surface and **circulatory system** transport substances to the body's cells.



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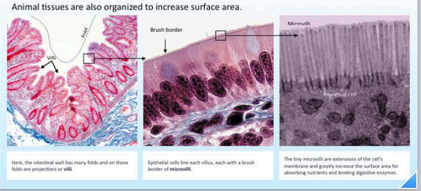
Multicellular Organisms

Animal tissues are also organized to increase surface area.



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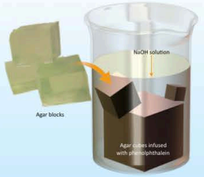
Surface Area and Cell Size



Oxygen, water, cellular waste, and many nutrients are transported into and out of cells by diffusion.

However, at a certain surface area to volume ratio, diffusion becomes inefficient.

Using **agar** block as model cells, the relationship between cell size and rate or efficiency of diffusion can be investigated.

The agar cubes are cut into cubes of various size and infused with **phenolphthalein** indicator, before being soaked in **sodium hydroxide** (NaOH).

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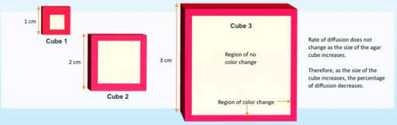
Surface Area and Cell Size

Phenolphthalein is an acid/base indicator. It turns pink in the presence of a base.

As the NaOH diffuses into the agar, the phenolphthalein changes to pink, indicating how far into the agar block the NaOH has diffused.



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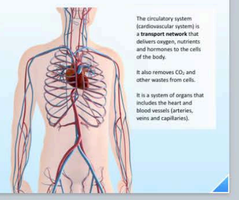
Exchanges with the Environment

The strategy an organism uses to **obtain the materials** it needs for survival and **eliminate its metabolic wastes** depends on the size of the organism and its lifestyle.

Single celled organisms can meet their needs by diffusion alone. Multicellular organisms must have mechanisms to overcome the size of their body.

- These include **regional specialization** (e.g. organs) and **transport networks** to remove wastes and move nutrients around to where they are needed.



The circulatory system (cardiovascular system) is a **transport network** that delivers oxygen, nutrients and hormones to the cells of the body.

It also removes CO_2 and other wastes from cells.

It is a system of organs that includes the heart and blood vessels (arteries, veins and capillaries).

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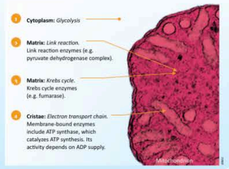
Efficiency Starts in the Cell

Membrane-bound organelles within cells increase metabolic efficiency for two reasons.

- Reaction pathways, such as cellular respiration, are restricted to a region where all the necessary metabolic components are located together.
- Because reactants and products must enter and leave reaction pathways by crossing a membrane, the rate of the reactions can be regulated more easily.



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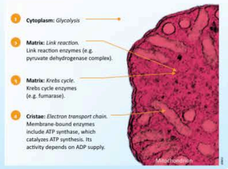
Efficiency Starts in the Cell

Enzyme activity in the respiratory pathways within the mitochondrion is regulated by levels of **ATP** and **NADH**.

ATP production itself is regulated by **ADP** supply.

The mitochondrion and its specialized internal structure enables the precise regulation of substrates and end-products.



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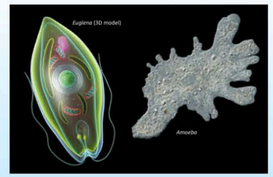
Exchanges in Simple Organisms



Single celled organisms (e.g. *Euglena*, *Amoeba*, and *Paramecium*) can meet their gas exchange requirements by simple diffusion or active transport directly across the plasma membrane.

Food is obtained by engulfing food particles to form membrane-bound food vacuoles (*Amoeba*) or by photosynthesis (*Euglena*).

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Exchanges in Simple Organisms

Some simple multicellular organisms, such as **flatworms**, can meet their gas exchange needs by simple diffusion across the body surface.

- Food is digested by secretion of enzymes outside the body. The digested material is taken up into a simple, highly branched gut.

In a similar way, **insects** have a network of tubes, which open to the outside and branch internally to allow gases to penetrate into the tissues.

Such systems are only effective for relatively small organisms.

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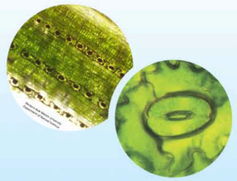
Exchanges in Vascular Plants



Plants must overcome two "supply and demand" difficulties.

- They must have a way to allow carbon dioxide into the leaf to provide the raw material for **photosynthesis**.
- They must also limit water loss.

The **stomata** (leaf pores), **guard cells** (flanking the stomata), and the plant cell **vacuole** all play important roles in permitting exchanges with the environment.

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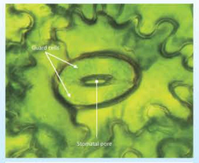
Exchanges in Vascular Plants

Stomata are pores in the epidermis of plants that, when open, allow water and gases to enter and leave the leaf.

Guard cells are specialized cells that occur in pairs flanking the stomata. They are unevenly thickened and control gas exchange through rapid changes in **turgor**.

- When they are swollen (turgid), the stomatal pore is open
- When they lose turgor, they collapse, closing the pore.



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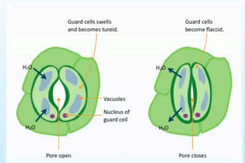
Exchanges in Vascular Plants



The closure of stomata reduces water loss but also prevents gas exchange.

Guard cells make these rapid turgor changes by regulating the movements of osmotically active solutes and so also the **osmotic pressure** of their vacuoles.

The vacuoles either take up or lose water, and consequently enlarge or shrink, changing the turgor of the cell.

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Exchanges in Vascular Plants

Plants depend on their **roots** to absorb water and nutrients from the soil.

The surface area available for these exchanges is greatly increased by the presence of **root hairs**. These root hairs are lateral extensions of single cells.

The root hair cells lack a waterproof cuticle so nutrient and water uptakes can be maximized.

Root hairs visible on germinating cannabis roots

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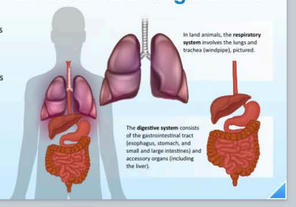
Exchange in Multicellular Organisms

Exchange networks in large organisms have specializations to maximize the efficiency of exchanges between the cells and their environment and so ensure exchange requirements are met.

These specializations are illustrated by the human respiratory, circulatory, and digestive systems.



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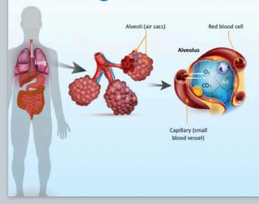
Exchange in Multicellular Organisms



In the **respiratory system**, air is taken into the **alveoli**, which lie adjacent to the lung capillaries and provide a large surface area for gas exchanges with the blood.

Oxygen diffuses from air in the alveoli into capillaries. CO_2 diffuses in the opposite direction.

The blood transports gases to and from the gas exchange surface. Together with breathing, this maintains the **concentration gradients** for diffusion.

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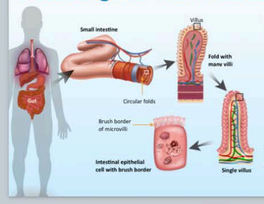
Exchange in Multicellular Organisms



In the **digestive system**, surface area for nutrient exchange is increased by several levels of organization.

- **1.** The small intestine is folded into circular folds.
- **2.** These folds bear many projections called villi, which are lined with epithelial cells.
- **3.** Each epithelial cell has a fringe of microvilli.

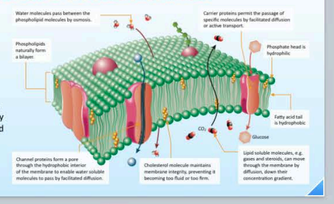
The large intestine has no villi. Its main function is to absorb water.

52

The Structure of Membranes

The **plasma** (or cell surface) **membrane** encloses the cell's contents and regulates many of the cell's activities.

Importantly, it controls what enters and leaves the cell by the use of carrier and channel proteins.



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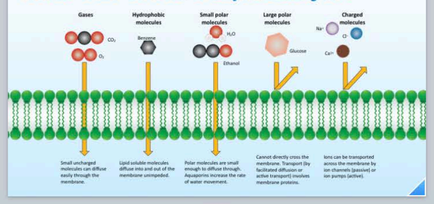
What Can Cross a Lipid Bilayer?



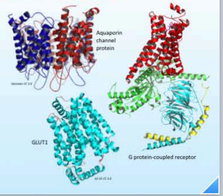
54

Models of Membrane Proteins

The **structure** of membrane proteins enables them to perform their particular function in transport, cell signalling, or cell recognition.

The proteins are integral to the membrane, and often have parts of their structure projecting from both internal and external sides of the membrane.

- There are two types of folding structure in membrane proteins: the **alpha helix** and the **beta pleated sheet**.



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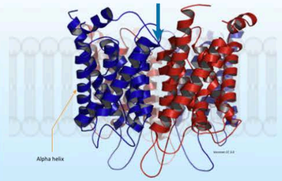
Models of Membrane Proteins



Aquaporins are a special type of channel protein that speed up the passage of water molecules across the membrane.

Their tertiary structure creates a pore through the centre of the protein through which molecules can pass (blue arrow).

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Models of Membrane Proteins

The **GLUT1** glucose transporter is a carrier protein that facilitates the transport of glucose across the plasma membranes of mammalian cells.

It increases the rate of glucose transport by 50,000X (this is high enough to supply the cell's energy needs).

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Models of Membrane Proteins

G protein-coupled receptors are proteins that are involved in signaling pathways.

A signal molecule binds to the receptor protein outside the cell to trigger a reaction involving intracellular G protein.

- In the example on the left, the receptor binds to adrenaline.

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Investigating Membrane Permeability

Membrane permeability can be disrupted if membranes are subjected to high temperatures or solvents.

- At temperatures above the optimum, the membrane proteins become **denatured**.
- Alcohols such as ethanol can also denature proteins.

Denatured proteins no longer function properly, and the membrane loses its selective permeability and becomes leaky.

The combination of alcohol and high temperature can also dissolve lipids.

Plant cells often contain a large central vacuole surrounded by a membrane called a **tonoplast**.

In beetroot plants, the vacuole contains a water-soluble red pigment called **betacyanin**, which gives beetroot its color.

If the tonoplast is damaged, the red pigment leaks out into the surrounding environment. The amount of leaked pigment relates to the amount of damage to the tonoplast.

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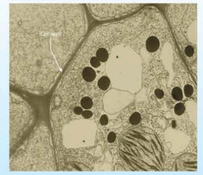
The Role of the Cell Wall



Cell walls are structural components of cells external to the plasma membrane.

- They are composed of complex carbohydrates: **cellulose** in plants, **chitin** in fungi and **peptidoglycan** in bacteria (although not *Archaea*).

Cell walls provide support and protection for the cell, preventing over-expansion when the pressure inside a cell rises.

In bacteria, cell wall composition is important in distinguishing bacterial groups and may also contribute to virulence.

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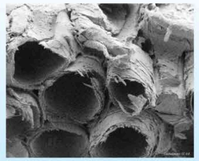
Functions of the Cell Wall



Xylem cell wall (plant)

Support: Maintains mechanical strength and supports the cell.

Offsets osmotic influx: Internal pressure from the cell's contents (**turgor** pressure) presses the plasma membrane against the cell wall. Turgor pressure limits cell volume and is important for supporting primary plant tissues.

Regulate growth: The cell wall helps regulate the cell cycle.

Storage: The cell wall is a major store of complex carbohydrate.

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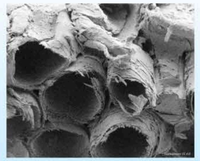
Functions of the Cell Wall



Xylem cell wall (plant)

Permeability: The cell wall is freely permeable to water, ions, and other small molecules including small proteins, but molecules larger than 60,000 Da can't cross, so the cell wall represents a permeability barrier to some molecules. Larger molecules can move between cells via cellular connections through the cell wall called plasmodesmata.

Protection: Because it excludes larger particles, the cell wall provides some protection against viruses and bacteria.

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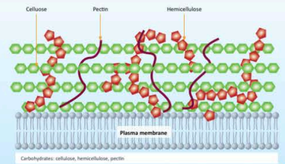
Plant Cell Walls

Plant cell walls have three major elements: cellulose, hemicellulose, and pectin.

Hemicellulose links the **cellulose** into a matrix.

This matrix is embedded with **pectin**, an acidic polysaccharide.



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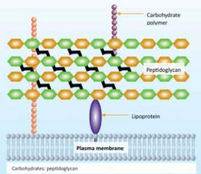
Bacterial Cell Walls



Bacterial cell walls are divided into two major groups, **Gram-positive** or **Gram-negative**, based on the wall's retention of a violet stain.

- Gram positive cell walls (right) contain more **peptidoglycan** than Gram negative walls, which have only a thin peptidoglycan layer sandwiched between an inner (plasma) and outer membrane.

Bacterial cell walls provide structural support and determine shape.

The composition of the wall also contributes to virulence and is a factor in antibiotic sensitivity.

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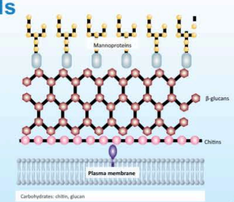
Fungal Cell Walls

Fungal cell walls are a unique structure of **chitin**, **β-glucans** (β-D-glucose polysaccharides), and **mannoproteins** (which are proteins with mannose sugar attached).

The wall provides cell rigidity and shape and helps the fungus adhere to nutrient-rich substrates.



65

Passive Transport

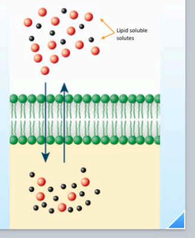
In biological systems, most diffusion occurs across membranes.

- Diffusion allows cells to make exchanges with their extracellular environment (e.g. the blood and fluids that bathe them) and is crucial to the regulation of water content.

In **simple diffusion**, molecules move directly through the cell membrane without assistance.

Example:

- O_2 diffuses into the blood and CO_2 diffuses out. Diffusion gradients are maintained because substances are constantly being imported. made. or used by the cell.



66

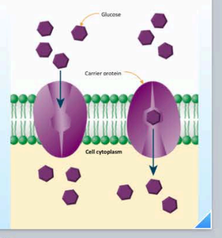
Passive Transport

In **facilitated diffusion**, molecules and ions are transported across a membrane by specific carrier and channel proteins in the membrane.

Carrier proteins in the membrane allow large lipid-insoluble molecules that cannot cross the membrane by simple diffusion to be transported into the cell.

Example:

- The transport of glucose into red blood cells.



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Passive Transport

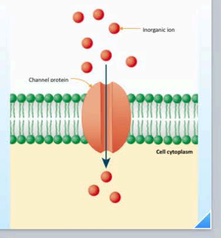
In **facilitated diffusion**, molecules and ions are transported across a membrane by specific carrier and channel proteins in the membrane.

Channel proteins (hydrophilic, water-filled pores) in the membrane allow inorganic ions to pass through.

Aquaporins are special channel proteins for rapid diffusion of water.

Example:

- K^+ ions exiting nerve cells to restore resting potential.



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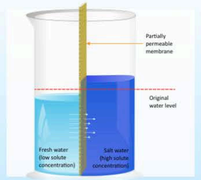
Osmosis



Osmosis is the diffusion of water molecules from regions of **lower solute** concentration to regions of **higher solute** concentration across a **partially permeable membrane**.

- A partially permeable membrane allows only certain molecules to pass through.
- The plasma membrane of a cell is a partially permeable membrane.

Water molecules will diffuse across a partially permeable membrane until an equilibrium is reached and net movement is zero. Osmosis is a **passive process** and does not require any energy input.

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Osmotic Potential

The presence of **solutes (dissolved substances)** in a solution increases the tendency of water to move into that solution.

This tendency is called the **osmotic potential** or **osmotic pressure**.

The more total dissolved solutes a solution contains, the **greater** its osmotic potential.

- A common example of a solution is a saline water solution made by dissolving table salt (the solute) in water (the solvent).
- Salt water has greater osmotic potential than fresh water.

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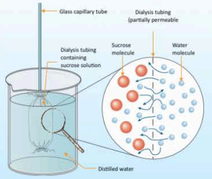
Demonstrating Osmosis



Osmosis can be demonstrated using dialysis tubing in a simple experiment.

- A **sucrose solution** (high solute concentration) is placed into dialysis tubing and the tubing is placed into a beaker of **distilled water** (low solute concentration).
- The difference in sucrose concentration between the solutions creates an **osmotic gradient**. Water moves by osmosis into the sucrose solution and the volume of the solution inside the dialysis tubing increases.
- The dialysis tubing acts as a partially permeable membrane, allowing water to

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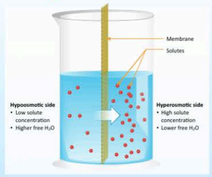
Osmolarity and Tonicity

Osmolarity and **tonicity** are related but distinct terms. Both are used to compare the solute concentrations of two solutions separated by a membrane.

- Terms ending in **-osmotic** are not equivalent to terms ending in **-tonic**.
- The difference relates to whether the solutes can cross the membrane (penetrating) or not (non-penetrating).

Osmolarity takes into account the total concentration of penetrating and non-penetrating solutes. The greater the solute concentration, the higher the osmolarity.



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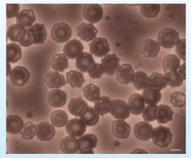
Osmolarity and Tonicity



The red blood cells above were placed into a hypertonic solution. As a result, the cells have lost water and shrunk, losing their discoid shape.

Tonicity is the measure of the osmotic pressure gradient between two solutions.

- It is only influenced by solutes that cannot cross the semipermeable membrane, since these are the only solutes influencing the osmotic pressure gradient.

Solutions are usually categorized as **isotonic**, **hypotonic**, or **hypertonic**, depending on the relative solute concentration across a membrane.

- **Isotonic:** Same solute concentration.
- **Hypotonic:** Lower solute concentration.
- **Hypertonic:** Higher solute concentration.

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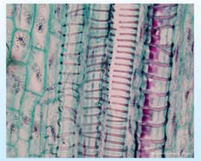
Water Relations in Plant Cells

The **water potential (ψ)** of a solution is the tendency for water molecules to enter or leave a solution by osmosis.

- The tendency for water to move into or out of a living cell can be calculated on the basis of the water potential of the cell sap relative to its surrounding environment.

Water potential is normally used to express water relations of plant cells.

- The terms osmotic potential and osmotic pressure are more often used in medicine and animal physiology.



The xylem transports water and nutrients from the roots to stems and leaves.

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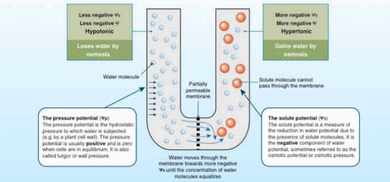
Water Potential and Water Movement



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Water Potential and Water Movement

Pressure on the membrane from water molecules is called **water potential (ψ)**. The greater the movement of water molecules, the higher their water potential.

- The presence of solutes (e.g. sucrose) lowers water potential because the solutes restrict the movement of water molecules.
- Pure water has the highest water potential (it has a water potential of zero).
- Dissolving any solute in water lowers the water potential (makes it more negative).

Water always diffuses from regions of less negative to more negative water potential.

Water potential is determined by two components:
- the **solute potential**, ψ_s (of the cell sap)
- the **pressure potential**, ψ_p

This is expressed by:

$$\Psi_{cell} = \Psi_s + \Psi_p$$

The closer a value is to zero (the potential of pure water), the higher its water potential.

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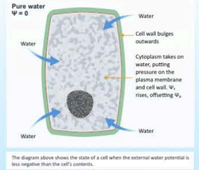
Turgor in a Plant Cell



When the contents of a plant cell push against the cell wall they create **turgor** (tightness). Turgor provides support for the plant body.

- When the external water potential is less negative than the Ψ_{cell}, water enters the cell.
- A pressure potential is generated when so much water has been taken up that the cell contents press against the cell wall.
- Ψ_p rises progressively until it offsets Ψ_s. Water uptake stops when the $\Psi_{cell} = 0$. The rigid cell wall prevents cell rupture.

Cells in this state are **turgid**.

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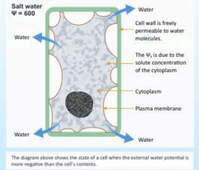
Plasmolysis in a Plant Cell



When cells lose water, there is a loss of turgor and the plant wilts. **Plasmolysis** is the complete loss of turgor from a cell.

- When external water potential is more negative than the water potential of the cell ($\Psi_{cell} = \Psi_s + \Psi_p$), water leaves the cell and, because the cell wall is rigid, the plasma membrane shrinks away from the cell wall.
- This process is termed plasmolysis and the cell becomes flaccid ($\Psi_p = 0$).
- Full plasmolysis is **irreversible** because the cell cannot recover by taking up water.

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Solute Potential and Cells

The **water potential of a plant cell** can be calculated by measuring the change in mass when cells are placed into solutions with a range of known concentrations.

- Cells placed into different concentrations will either gain or lose water depending on whether their internal water potential (ψ) is higher or lower than the solution's.
- Cells with a water potential equal to the surrounding solution will neither gain or lose water (mass).

A solution in an open beaker has no pressure acting on it ($\psi_p = 0$).

For cells in this system, the only important factor in determining a cell's water potential is the solute potential of the solution.

If the cell neither gains nor loses water, then its water potential is equal to the solute potential of the solution:

$$\psi_{cell} = \psi_{beaker} = \psi_{(beaker)} (=0) + \psi_{(beaker)}$$

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Solute Potential

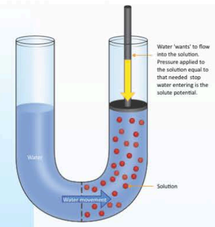
Solute potential is the pressure needed to be applied to a solution to stop the inward flow of water across a partially permeable membrane due to solutes.

It is always negative in a plant cell and zero in distilled water. It is measured in **bars** (1 bar = 1 atmosphere at sea level).

Solute potential can be calculated using the formula:

$$\psi_s = -iCRT$$

- i = ionization constant (number of particles produced per unit when dissolved).
- C = molar concentration (mol/L)
- R = pressure constant = 0.0831 liter bars/mole K



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Active Transport

Active transport is the movement of molecules (or ions) from regions of low concentration to regions of high concentration across a cellular membrane by a **transport protein**.

Active transport can be used to move molecules into and out of a cell.

- Active transport needs energy to proceed because molecules are being moved **against their concentration gradient**.
- This energy comes from the **hydrolysis** of ATP to ADP and inorganic phosphate (P_i).

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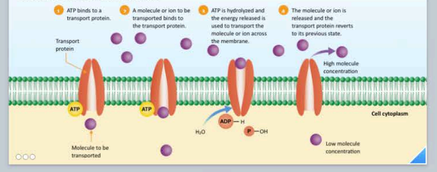
Active Transport

Transport (carrier) proteins in the membrane are used to actively transport molecules from one side of the membrane to the other.



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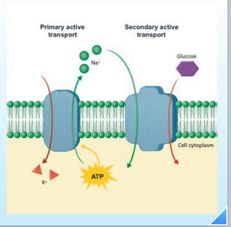
Active Transport

Active transport can be either primary or secondary.

Primary active transport directly uses ATP for the energy needed to transport molecules.

In **secondary active transport**, energy is stored in a concentration gradient.

- The transport of one molecule is coupled to the movement of another down its concentration gradient, and ATP is not directly involved in the transport process.



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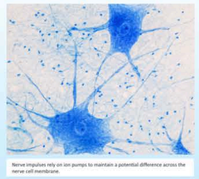
Ion Pumps



Nerve impulses rely on ion pumps to maintain a potential difference across the nerve cell membrane.

Ion pumps are used to transport molecules or ions across the membrane against their concentration gradient.

- Ions are charged, so their movements can create a potential difference (voltage) across membranes.

The combination of concentration gradient and voltage that affects an ion's movement is called an **electrochemical gradient**.

The electrochemical gradient created by ion pumps is often coupled to the transport of other molecules across the membrane.

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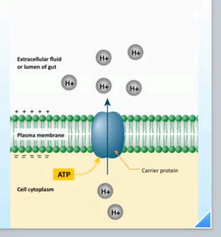
Proton Pumps

Proton pumps create a potential difference across a membrane by using energy (ATP or electrons) to move H^+ from one side of the membrane to the other.

This difference can be coupled to the transport of other molecules.

- In cellular respiration and the light reactions of photosynthesis, the energy for moving the H^+ comes from electrons.
- The flow of H^+ back across the membrane drives ATP synthesis via the membrane-bound enzyme ATP synthase.



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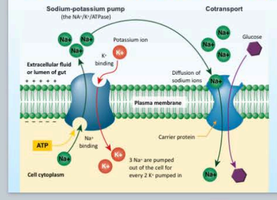
Sodium-Potassium Pump



The **sodium-potassium pump** is a transmembrane protein that uses energy from ATP to exchange Na^+ for K^+.

The unequal balance of Na^+ and K^+ across the membrane creates large electrochemical gradients that can be used to drive transport of other substances.

- The Na^+/K^+ pump also helps to maintain ion balance and so helps regulate the cell's water balance.

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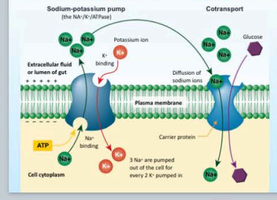
Cotransport (Coupled Transport)



A sodium ion gradient drives the active transport of **glucose** in intestinal epithelial cells.

- A specific transport protein couples the return of Na^+ down its electrochemical gradient to the transport of glucose into the intestinal epithelial cell.
- Glucose diffuses from the epithelial cells into the blood.

A low intracellular concentration of Na^+ is maintained by a

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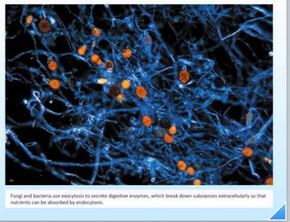
Cytosis

Cytosis is an active process involving the plasma membrane.

- In **exocytosis**, vesicles merge with the plasma membrane to export material from the cell.
- **Endocytosis** is a general term for engulfing of material by infolding of the plasma membrane.

Both of these processes require energy.



Fungi and bacteria use exocytosis to secrete digestive enzymes, which break down substances extracellularly so that nutrients can be absorbed by endocytosis.

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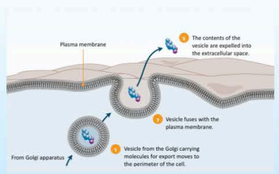
Exocytosis



Exocytosis is an active transport process in which a secretory vesicle fuses with the plasma membrane and expels its contents.

- In multicellular organisms, various types of cells are specialized to manufacture products, such as proteins, and then export them from the cell to elsewhere in the body or outside it.

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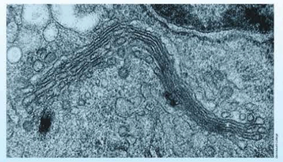
Exocytosis



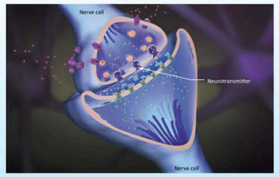
Golgi apparatus forming vesicles

The transport of Golgi vesicles to the edge of the cell and their expulsion from the cell occurs through the activity of the cytoskeleton.

This requires energy (ATP).

90

Exocytosis



Exocytosis is important in the **transport of neurotransmitters** into the junction (synapse) between nerve cells to transmit nervous signals.

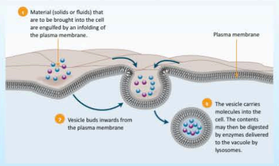
Neurotransmitters are signalling molecules secreted by a neuron. They are transported across synapses to affect another cell.

91

Endocytosis

Exocytosis is an active transport process in which a secretory vesicle fuses with the plasma membrane and expels its contents.

- In multicellular organisms, various types of cells are specialized to manufacture products, such as proteins, and then export them from the cell to elsewhere in the body or outside it.



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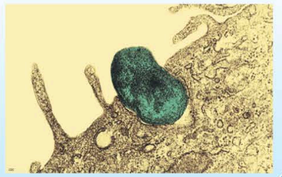
Endocytosis

Phagocytosis involves the cell engulfing solid material to form large phagosomes or vacuoles.

It may be non-specific or receptor-mediated.

Examples:

- Feeding in *Amoeba*
- Phagocytosis of foreign material and cell debris by neutrophils and macrophages.



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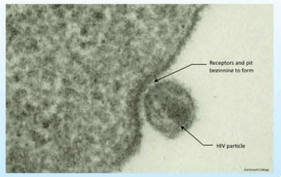
Endocytosis

Receptor mediated endocytosis is triggered when certain metabolites, hormones, or viral particles bind to specific receptor proteins on the membrane so that the material can be engulfed.

Examples:

- Uptake of lipoproteins by mammalian cells.
- Endocytosis of viruses.



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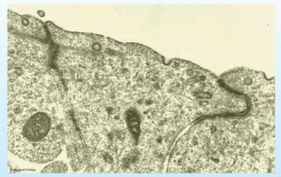
Endocytosis

Pinocytosis involves the non-specific uptake of liquids or fine suspensions into the cell to form small pinocytic vesicles.

Pinocytosis is used primarily for absorbing extracellular fluid.

Examples:

- Uptake in many protozoa, some cells of the liver, and some plant cells.



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Compartments in Cells

Cells create compartments (**organelles**) using membranes. The compartmentalization of certain operations increases the cell's overall efficiency, because specific areas are focused on specific tasks.

Like the plasma membrane, the membranes of organelles control entry and exit of materials to and from their compartments.

Membranes also allow attachment of proteins for specific tasks and help create chemical gradients to power the biochemical reactions necessary to sustain life.

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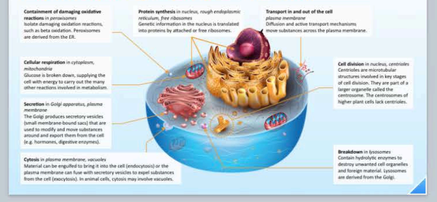
Processes in an Animal Cell



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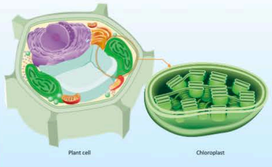
Plants Carry Out Photosynthesis



Photosynthesis is the process process by which plants use sunlight, water, and carbon dioxide to create oxygen and energy in the form of sugar.

Chloroplasts are membrane-bound organelles that are the site of photosynthesis.

They capture light energy and convert it into useful chemical energy (as sugars).

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Compartmentalization of Processes

Membranes play an important role in separating regions within the cell (and within organelles) where particular reactions occur. Specific enzymes are often located in particular organelles.

The reaction rate is controlled by controlling the rate at which substrates enter the organelle and therefore the availability of the raw materials required for the reactions.

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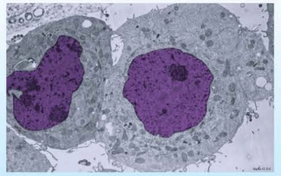
Compartmentalization of Processes



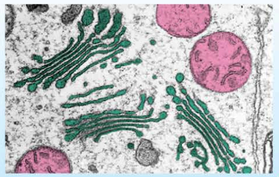
The **nucleus** is surrounded by a double-membrane structure called the nuclear envelope, which forms a separate compartment containing the cell's genetic material (DNA).

100

Compartmentalization of Processes

The **Golgi apparatus** (green) is a specialized membrane-bound organelle.

It compartmentalizes the modification, packing, and secretion of substances such as proteins and hormones.



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Compartmentalization of Processes

The inner membrane of a **mitochondrion** provides attachments for enzymes involved in cellular respiration.

It allows ion gradients to be produced that can be used in the production of ATP.

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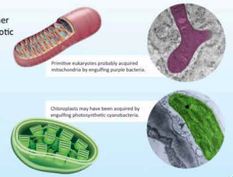
Origins of Cellular Compartments

It is thought that eukaryotic cells evolved from pre-eukaryotic cells that ingested other free-floating bacteria, and formed a symbiotic relationship with the cells they engulfed.

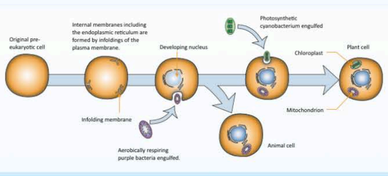
This hypothesized process is called **endosymbiosis**.

The two organelles that evolved in eukaryotic cells as a result of bacterial endosymbiosis were **mitochondria**, for aerobic respiration, and **chloroplasts**, for photosynthesis in aerobic conditions.



103

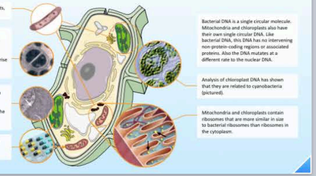
Evolution of Eukaryotic Cells



104

Evidence for the Origins of Organelles

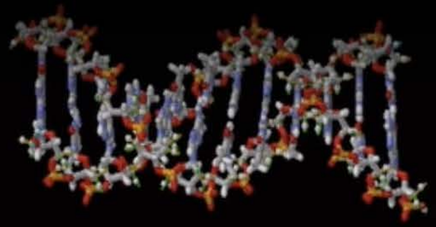
Evidence for the bacterial origin of chloroplasts and mitochondria by endosymbiosis includes:



105

LS4A - Evidence of Common Ancestry and Diversity

Disciplinary Core Idea LS4A:



Share

Evidence of Common Ancestry and Diversity

MORE VIDEOS

Next Generation Science Standards

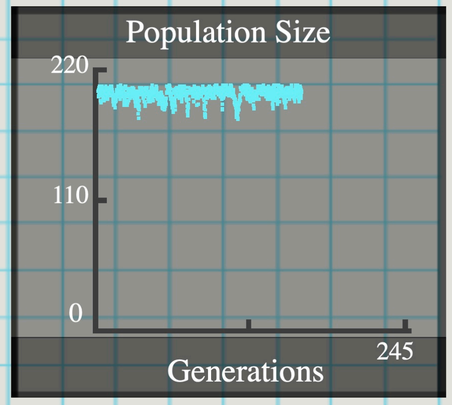
Not Secure — virtualbiologylab.org/ModelsHTML5/PopGenFishbowl/PopGenFishbowl.html

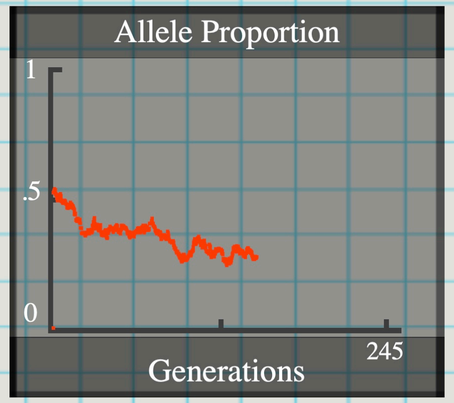
BIOZONE World

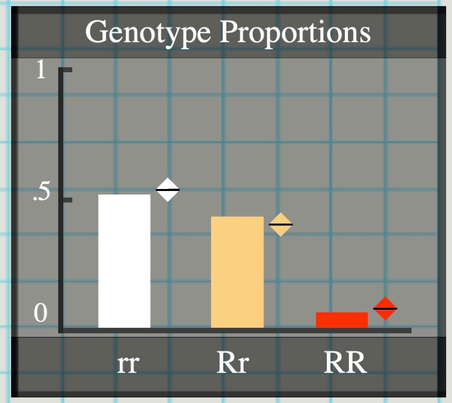
PopGen Fishbowl - Virtual Biology Lab

Data Collection

Generations	117
Population Size	199
Proportion R allele	0.27
Proportion r allele	0.73
Prop. rr Genotype	0.51
Prop. Rr Genotype	0.43
Prop. RR Genotype	0.06

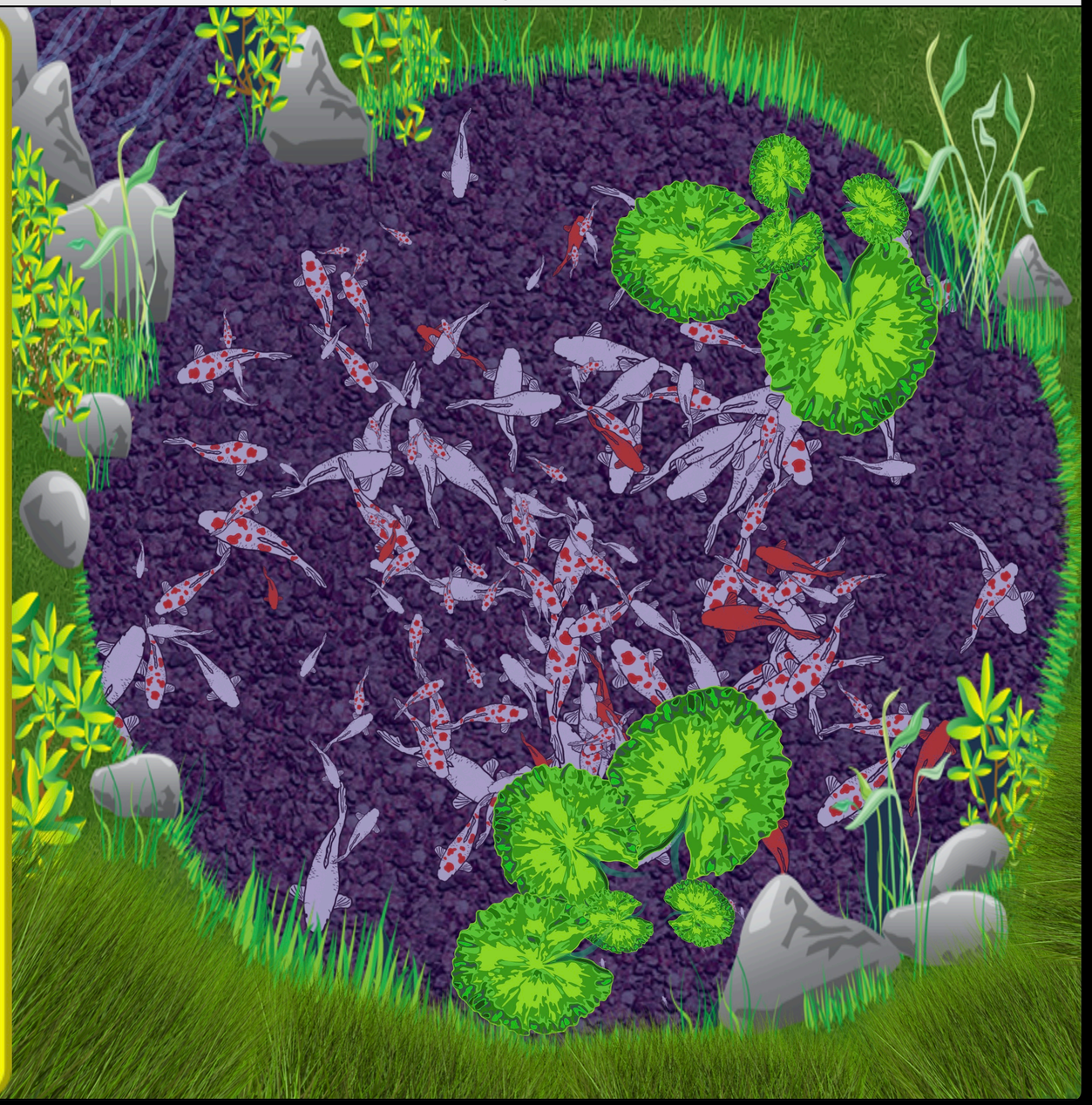






4X

To Design



104% No Presets

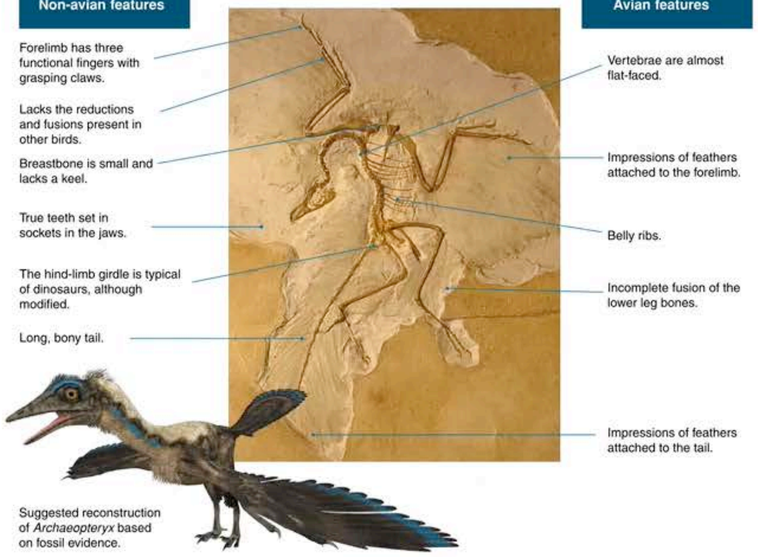
225 Transitional Fossils

Key Question: How do transitional fossils provide important links in the fossil record?

Transitional fossils are **fossils** which have a mixture of features, showing intermediate states, that are found in two different, but related, groups. Transitional fossils provide important links in the fossil record and provide evidence to support how one group may have given rise to the other by evolutionary processes.

Important examples of transitional fossils include horses, whales, and *Archaeopteryx* (below), a transitional form between birds and non-avian dinosaurs.

Archaeopteryx was crow-sized (50 cm length) and lived about 150 million years ago. It had a number of birdlike (avian) features, including feathers. However, it also had many non-avian features, which it shared with theropod dinosaurs of the time. Although not a direct ancestor of birds, the *Archaeopteryx* and birds shared a common ancestor.



Suggested reconstruction of *Archaeopteryx* based on fossil evidence.

1. (a) What is a transitional fossil? _____

(b) Why are transitional fossils important in understanding evolution? _____

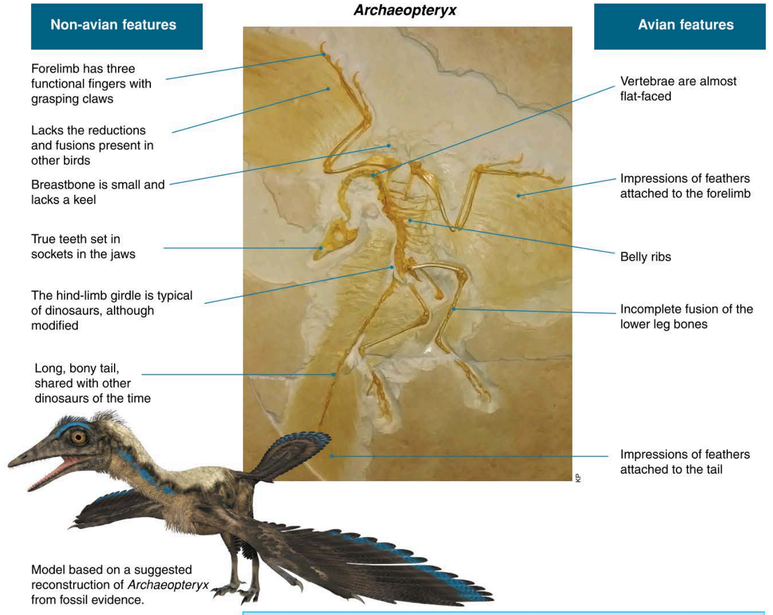
LS4.A P

ISBN: 978-1-98-856692-4

124 Transitional Fossils

Key Idea: Transitional fossils show intermediate states between two different, but related, groups. They provide important links in the fossil record

Transitional fossils are fossils with a mixture of features found in two different, but related, groups. Transitional fossils provide important links in the fossil record and provide evidence to support how one group may have given rise to the other by evolutionary processes. Important examples of transitional fossils include horses, whales, and *Archaeopteryx* and other non-avian feathered dinosaurs (below). *Archaeopteryx* was a transitional form between non-avian dinosaurs and birds. *Archaeopteryx* was crow-sized (50 cm length) and lived about 150 million years ago. It is regarded as the first primitive bird and had a number of birdlike (avian) features, including feathers. However, it also had many non-avian features, which it shared with theropod dinosaurs of the time.



Model based on a suggested reconstruction of *Archaeopteryx* from fossil evidence.

1. (a) What is a transitional fossil?

(b) Why are transitional fossils important in understanding evolution?

2. (a) Identify one feature of *Archaeopteryx* that clearly shows it is related to reptiles:

(b) Identify one feature of *Archaeopteryx* that clearly shows it is related to modern birds:

ISBN: 978-1-98-856637-5

Non-avian features

Forelimb has three functional fingers with grasping claws.

Lacks the reductions and fusions present in other birds.

Breastbone is small and lacks a keel.

True teeth set in sockets in the jaws.

The hind-limb girdle is typical of dinosaurs, although modified.

Long, bony tail.

Avian features

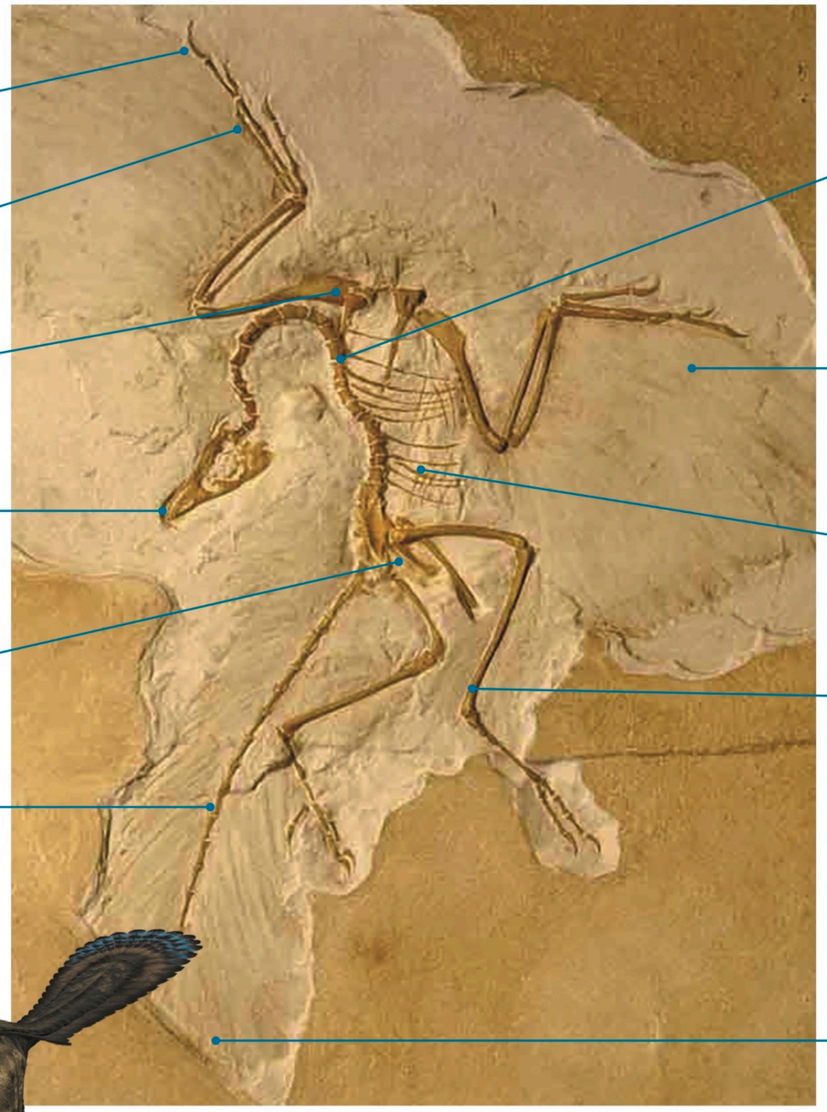
Vertebrae are almost flat-faced.

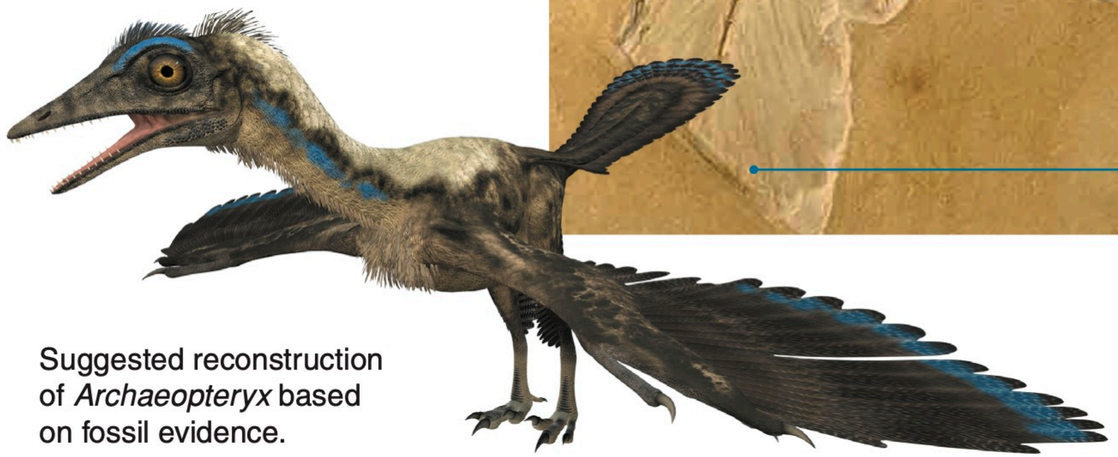
Impressions of feathers attached to the forelimb.

Belly ribs.

Incomplete fusion of the lower leg bones.

Impressions of feathers attached to the tail.





Suggested reconstruction of *Archaeopteryx* based on fossil evidence.

sockets in the jaws.

The hind-limb girdle is typical of dinosaurs, although modified.

Long, bony tail.

Suggested reconstruction of *Archaeopteryx* based on fossil evidence.

Two licence types in **BIOZONE World** are:

STUDENT Access

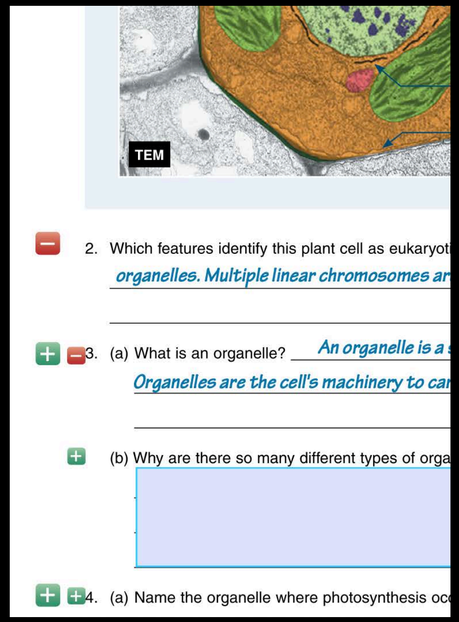
Digital interactive replica of the book:

- **Digital replica**: students can view the book, add **annotations** and **markup**.
- Students can enter **answers online** and **submit** them to their teacher.
- Digital resources available: **3D models**, **presentation slides**, curated OER **videos**, **weblinks**.

TEACHER Access

All the functions the student has plus:

- Teacher has access to **model answers** via display buttons.
- Teacher can **assign activities** as time-sensitive coursework to be submitted by students.
- Teacher can **view**, **comment** and **grade** student responses to questions.



- Access to BIOZONE WORLD is obtained by purchase of **institutional** (school) **licences** to specific book titles.
- A **minimum of 20 licences** per title must be purchased.
- Licences are **annual subscriptions** - multiyear license options are available.

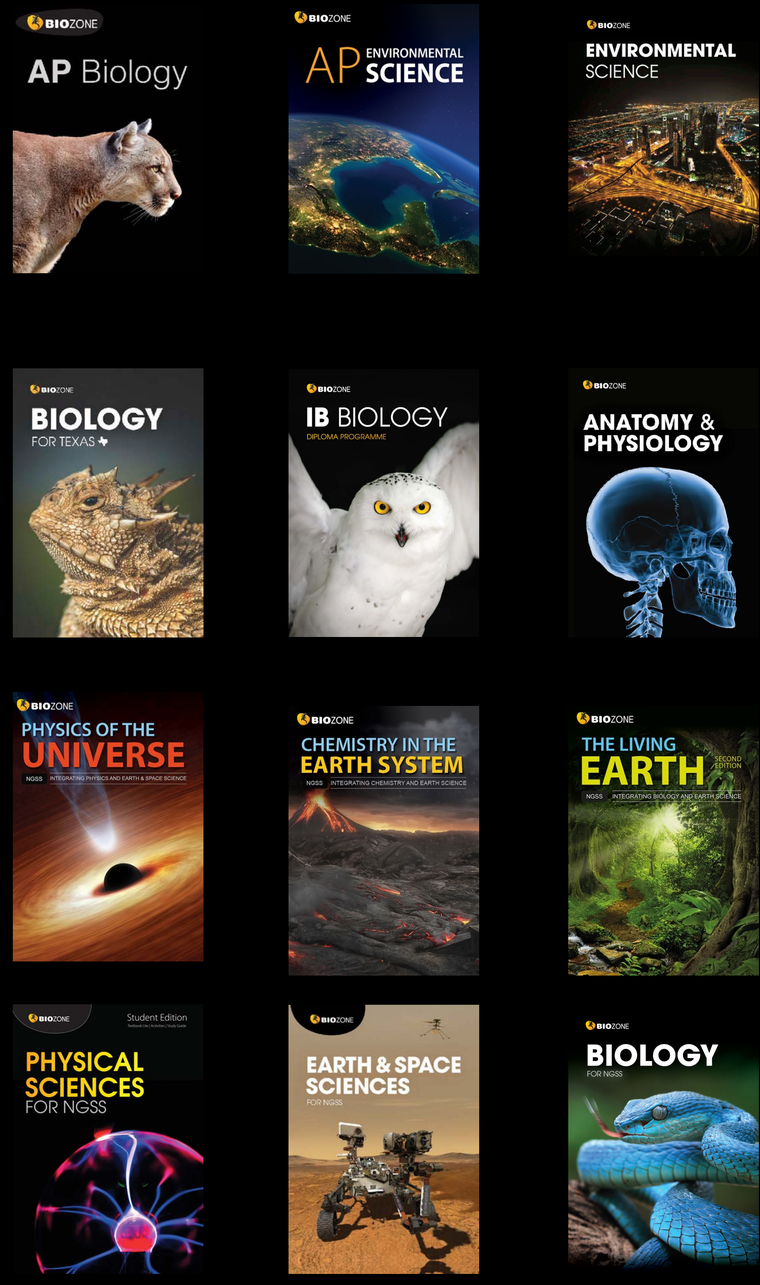
BIOZONE WORLD

Full Teacher Preview

ALL 20 titles

free for 30 days

*and you could also **WIN** 1 year free access*
*to the title of your choice for you and your class**



BIOZONE.com/us/bw-trial

If you like what you see ....
you can also request a **90-Day classroom trial** of a complete program of your choice.

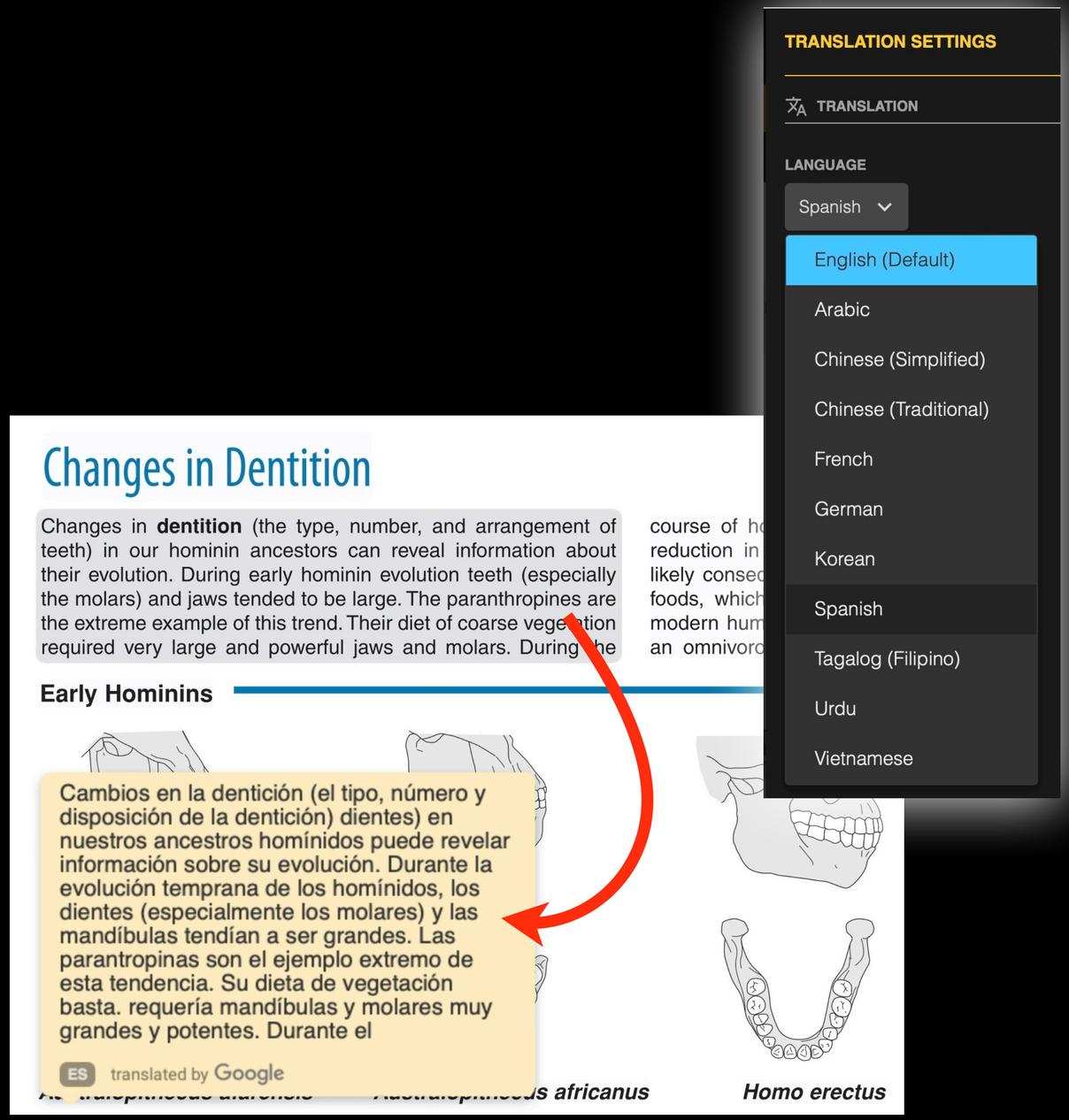
You will also have access to:

- **BIOZONE WORLD User Guide**
- **BIOZONE Virtual Lab** (experimental)

Translation **Feature**

- **Translation for 150 languages:** Realtime translation - highlight the English text to display text translation in the selected language (25 languages active).

- Once activated, pointing the mouse at a text block in the book page will show the translated version on a nearby pop-up panel.



Apps

All Bookmarks

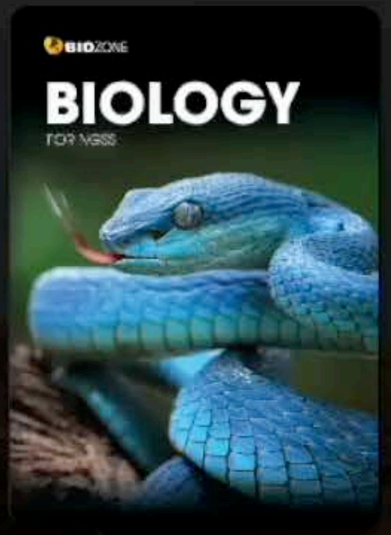
BIOZONE ALPHA

LA

CLASS A

DASHBOARD ASSIGNMENTS

STANDARD NGSS



NEXT ASSIGNMENT SUN OCT 01 2023

Test case 1

REMINDERS

SCIENTIFIC AMERICAN

Features In Development

- **Accessibility** well advanced for students with disabilities.
- Text **reading level simplification** in real time (experimental)
- Teacher will be able to add links to their **own resources** (files and links)
- Integration with **LMS platforms**:
  e.g. *Google Classroom*, *Canvas*, *Schoology*, etc.
- **Personal Licences**: single-user, untethered to an institution

BIOZONE WORLD

User Guide

USER GUIDE

Version 1.4

BIOZONE has launched BIOZONE WORLD, a stunning new science content delivery platform. This new platform brings all of our digital resources together for easy access and an immersive teaching and learning experience.

BIOZONE WORLD incorporates your choice of digital replicas of our highly acclaimed print titles (see the 30+ titles on the last page of this document) together with our rich collection of online resources:

- **Digital replicas** of our **books** with student ability to answer free response questions
- **Presentation slides**
- **3D models**
- curated OER **videos**
- links to third-party **websites**

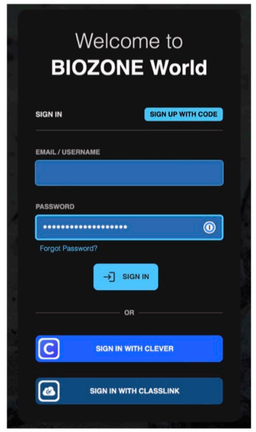
This provides powerful and flexible options for delivering your school science programs.

Quick Start Guide

Go to the web site: world.BIOZONE.com

Registering and Logging On:

Sign in to your account using one of three methods:

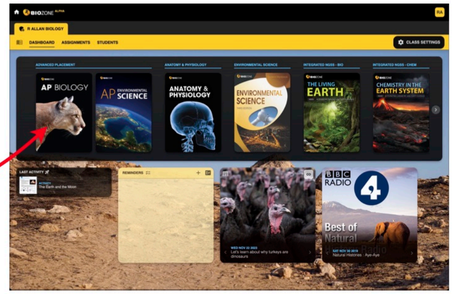


1. **SIGN IN**: Enter your registered **email address** and **password** (this may already have been set up by your school IT Admin)

2. **SIGN UP WITH CODE**: Enter a code supplied to you to enrol in the platform (if you have been provided one by your IT Admin).

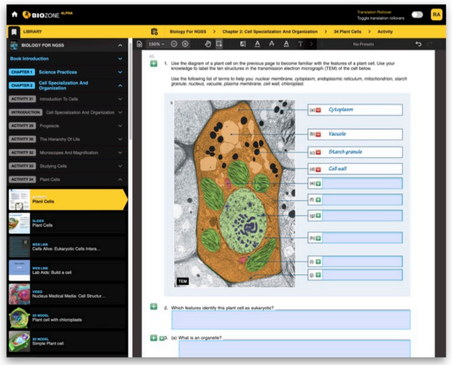
3. **ROSTERING SERVICE:** sign in with **ClassLink** or **CLEVER** (if your school is subscribed to these single sign-on integrations).

4. **HOME SCREEN**: Click on the book title cover you see here. Your licence may give you access to more than one book, so click the RIGHT ARROW button to show any additional titles out of sight.



5. **EXPLORE THE BOOK**:
   Click on the chapter titles (blue), and then the individual activity titles (grey). This will display the pages of the book.
   Your licence may provide limited access to some features. You should be able to view pages, and access the linked resources attached to each activity:
   - **Presentation Slides**
   - **3D Models**
   - **Videos**
   - **Weblinks**

   NOTE: Some weblinks and videos require to be opened in a new TAB in your browser.



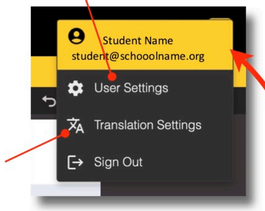
Dashboard | Home Screen:

Once logged in you will be presented with the Home Screen (depicted below).
The home screen allows you to see the **Dashboard.**

DASHBOARD Displays:

- **Book titles** that are registered to your account
- **Last Activity** that you were working on or accessed
- **Podcasts & RSS science news feeds** from science journals and magazines
- **Reminders** for things like due dates for assignments.
- **Assignments** (allows teacher to set assignments, monitor student progress)
- **Students** (allows teacher to manage class lists)

User Settings: Turn ON/OFF dashboard feeds (podcasts and RSS news feeds).



Translation Settings: Activate and choose from a list of languages for on-screen translation from English.

Account Details: Show your licence, user preferences and ability to Log Out.

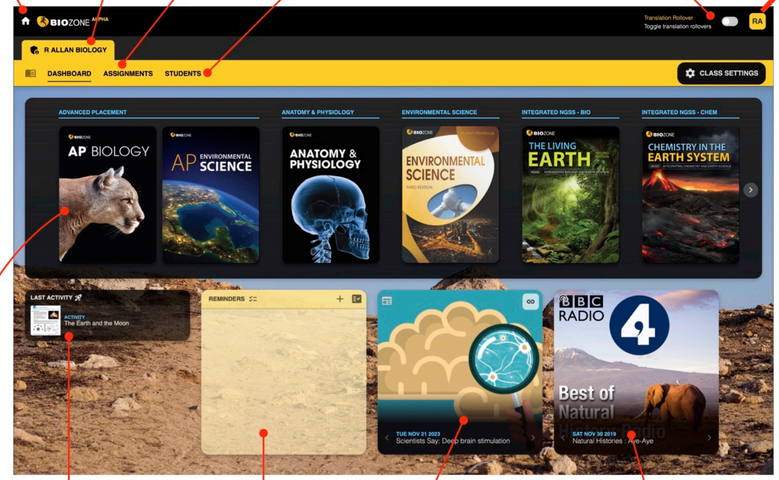
Home: Navigate back to the home screen by clicking on the BIOZONE logo or home icon

Your Classes: Your classes will show here (you may have more than one class)

Assignments: Allows teacher to set activities as assignments to whole classes or individual students.

Students: Lists students assigned to the class. Teachers can manage class lists and create groups.

Translation Toggle: Once translation is activated, this slider switch allows you to turn translation on or off.



Go To Last Activity: This provides quick access to the work in progress

Titles Available: Access the books that are licensed to your account. Use left and right arrows to view more book titles attached to your account (that are hidden from view).

Reminders: Widget to create your own personal reminders or 'To Do' lists.

RSS Science News Feeds: Access live news feeds to several science journals and magazines that are refreshed daily, including:
- ***Scientific American***
- ***New Scientist***
- ***Science News***

Science Podcasts: Access live feeds to several science podcasts that are refreshed daily, including:
- ***BBC Radio 4***
- ***Nature Journal***

Accessing a Book

When a student logs on to BIOZONE WORLD, the dashboard shows the book title attached to their account. Click on the book title to open the book and start exploring.

Student Access Features:

- **Interactive Replicas** of the printed books allow students to answer questions online …

  … this forms a "Record of Work" and may be graded by the teacher (if desired).

- **Presentation Slides**: Many of the activities have a selection of presentation slides that can be used by the teacher to provide context and background notes for the students - great for introducing a lesson - or reviewing at the end.

TEACHER VIEW shown below:

Library Toggle:
Click this button to show or hide book pages and resources.

Chapter Title:
All chapters are displayed in blue.

Activity Title:
Activities are numbered and displayed in grey

QR Codes: Some of our newer books feature QR codes. A student can use their mobile phone or tablet to scan this code and link to a 3D model.

Book Title:
More than one book may be displayed.

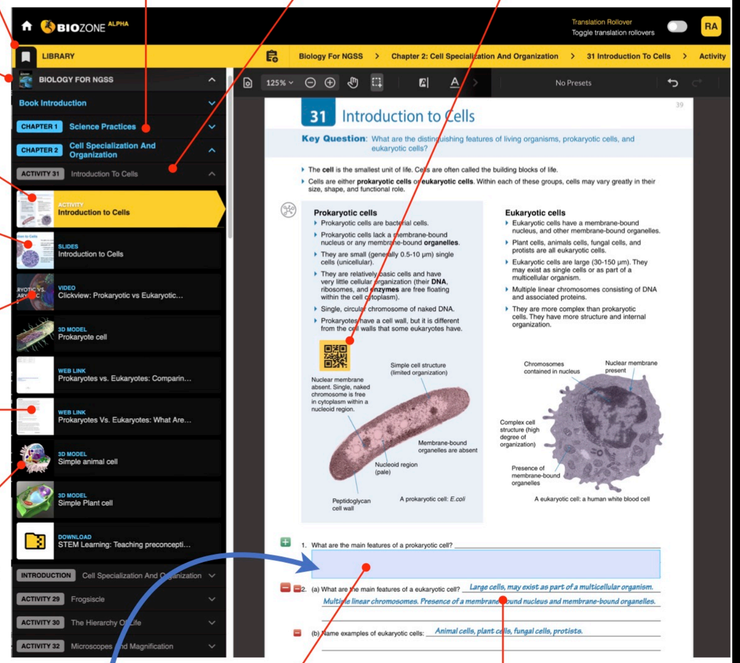
Activity Pages:
May be a single page or several pages.

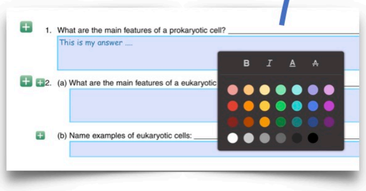
Presentation Slides:
Any slides relevant to the activity will be accessed here.

Curated Videos:
Mostly hosted on YouTube, these play within the platform.

Curated Web-links:
These will display in a new TAB in your browser as some have special display requirements.

3D Models: BIOZONE's collection of 3D models are often annotated and a provide a great lesson enrichment opportunity.





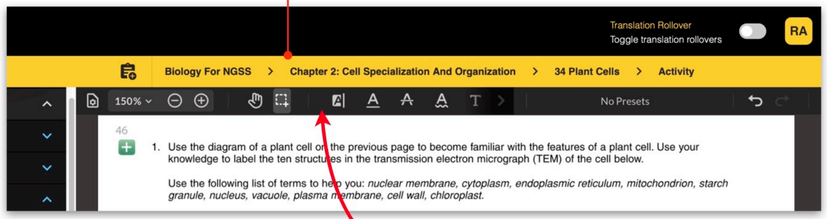
Student Responses:
Students double-click on one of the blue fields to type in their responses to questions.

Reveal Answers:
Teacher Only access - Use the (+) and (-) buttons to display or hide the suggested answers. HINT: use this feature with an interactive whiteboard to review a lesson.

Additional Features

Don't get lost - there is a clear roadmap of where you are currently in any title in BIOZONE World:

Breadcrumbs:
This shows you the path of where you are in any book



Tool Bar: There are various tools available to highlight, markup and comment on the page. See the explanation below.

Student Annotations and Markup

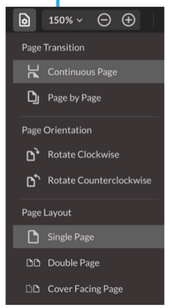
Students can add their own additional notes, draw on the page and highlight text passages.

Page Display Options:
There are various options to improve the way the pages of the book are displayed. When viewing videos and 3D models, you may wish to hide the navigation panel.

Select (Esc): Use this to select text on the page

Pan (P): Use this to grab the page and move it around

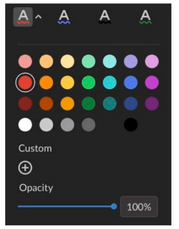
Markup Tools: Use markup tools to highlight, markup and comment on the page (keyboard shortcuts are shown in brackets).



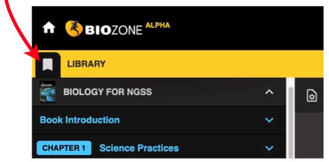
Highlight **(H)** Underline **(U)** Squiggly **(G)** Rectangle **(R)** Free Hand Highlight

Strikeout **(K)** Free Text **(T)** Free Hand **(F)**

Markup Pallet



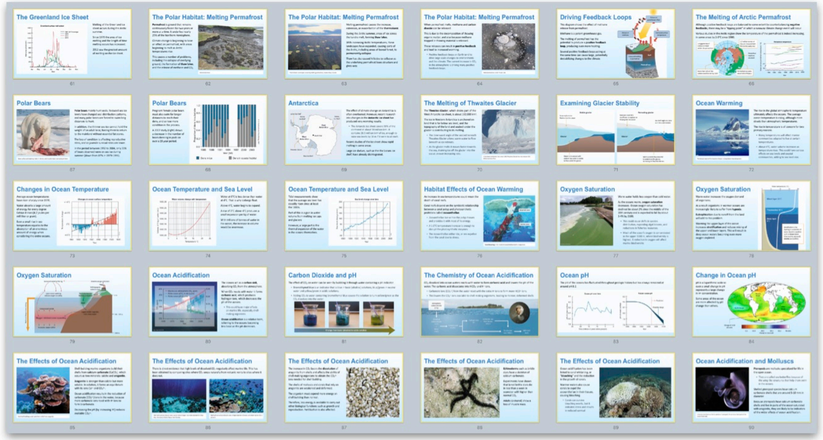
HINT: Library Icon
Click this library/bookmark icon - if you wish to **temporarily hide** the library index



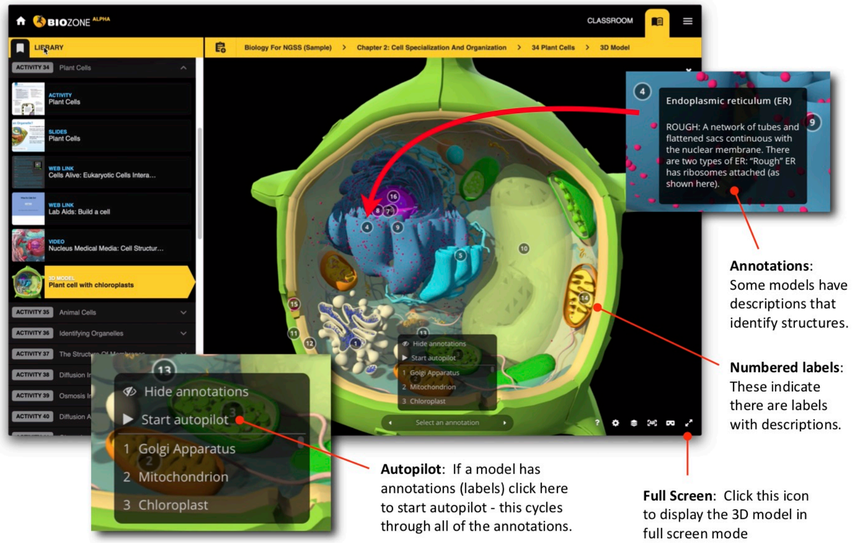
Access to Resources

Excellent interactives are provided with direct access to BIOZONE's own proprietary resources:

- **Presentation Slides**: Hundreds of slides are provided for each book title. These are grouped to suit each activity. Not every activity has a slide, while some activities can have several slides. These may be used to introduce a lesson or during the review at the end of a lesson.

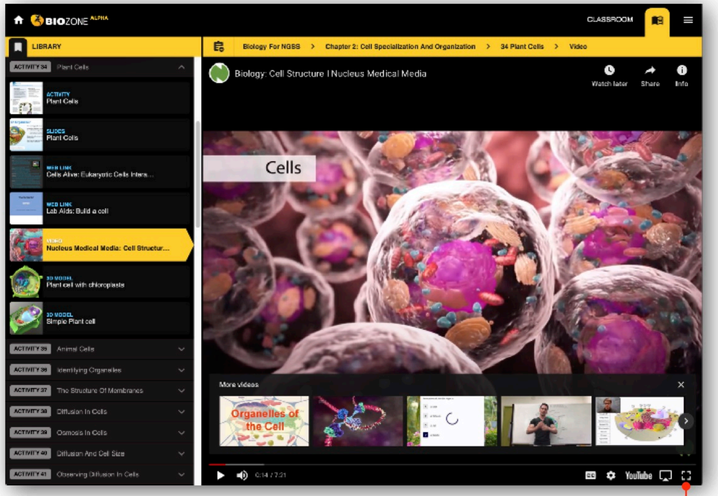


- **3D Models**: A rich collection of 3D models are provided for many activities. These create *"engagement moments"* for the student. Some are there for making a connection with the subject matter, while others provide detailed additional information - especially when the models are **annotated** with **descriptions**. Students can manipulate the models to understand structures, zooming in and out, and rotating them. Some models are also animated to illustrate a process or a behavior of a living organism.

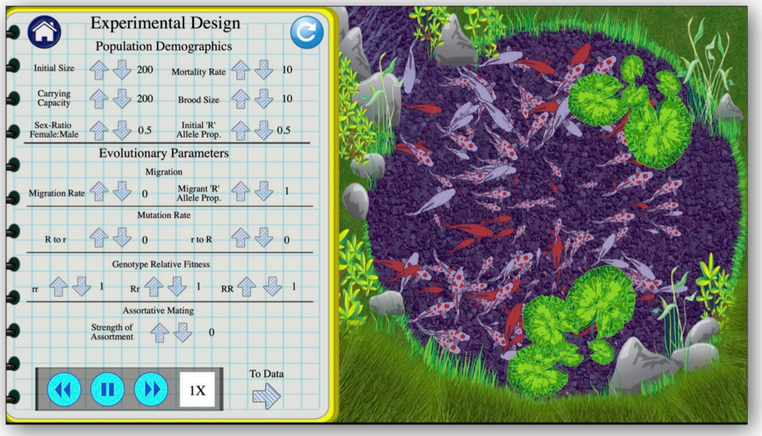


Open Educational Resources **Enrichment Content**

- **Curated OER Videos**: BIOZONE has curated a comprehensive library of videos from third party providers. Carefully selected and reviewed, these short videos can often add real value to a lesson. Most video content is hosted by **YouTube**, therefore your school IT administrator must allow access to that source to enable this function.

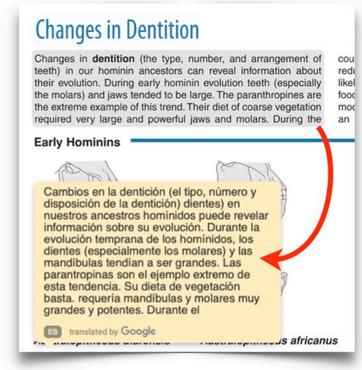


- **Web Links to OER websites**: A variety of Open Educational Resources provide excellent material to enhance your lessons. BIOZONE has curated a useful collection to augment most lessons (the one shown below is an online simulation). Because many of these websites have specific requirements to function, they will always open in a new TAB in your browser. An example is shown below:



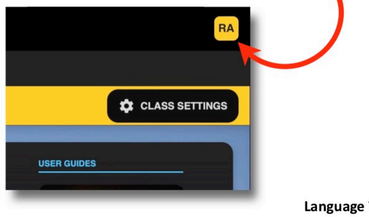
Language Translation - A New Experimental Feature

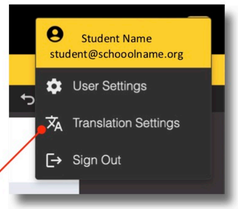
BIOZONE has released a *new experimental feature* - the realtime translation of highlighted (English) text into any of **150 other languages**, using the Google Translate service. The 25 most commonly requested languages are currently active. This feature is experimental because we wish to test the performance of the service with real customer data, as well as evaluate how well it performs as a solution to support English Language Leaners (ELL students). We will be seeking feedback from our customers about how well it is solving the problem: how to support English-language learners with such a diverse range of homeland languages.



How it Works:

1. Go to the top right hand corner of the screen and **click on the User Account** (here shown as RA).



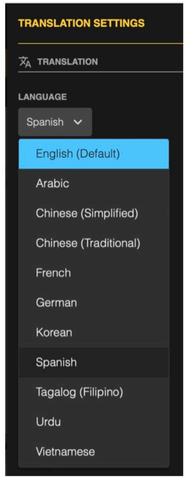


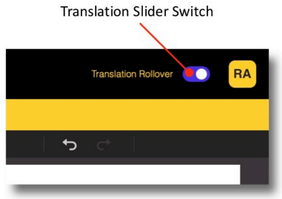
Language Translation: Choose from a list of languages for on-screen translation from English.

2. Choose **Translation Settings**: to select which language (see panel right):

   Currently 10 languages are available, with more to be added as soon as testing permits. You can change the language displayed at any time by going back to the Translation Settings. Click on the desired language.

3. Once activated, pointing the mouse at a text block in the book page will show the translated version on a nearby pop-up panel. A **slider switch** will appear at the top right-hand side of the screen. This allows you to turn OFF and turn back ON the translation function at any time.





Limitations:

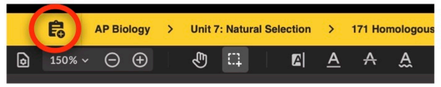
- Translates only text from the book itself.
- **Does not translate student answers**, nor any annotations (notes) that the student applies.
- **Does not translate the resources** listed in the library (videos, 3D models, Websites).

Assignments

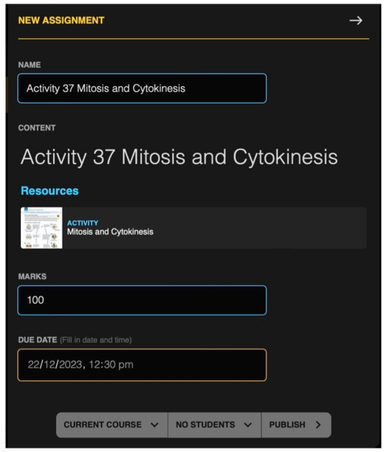
BIOZONE has developed a simple process for assigning activities in our books for students to do as time-sensitive assignments. It is assumed that, *before you create assignments*, you have already had students assigned to your class, along with one or more book titles.

Teacher Creates an Assignment:

1. Navigate to the **Activity Page** in the book which you wish to assign to your students.
2. Click on the Assignments icon (circled right):



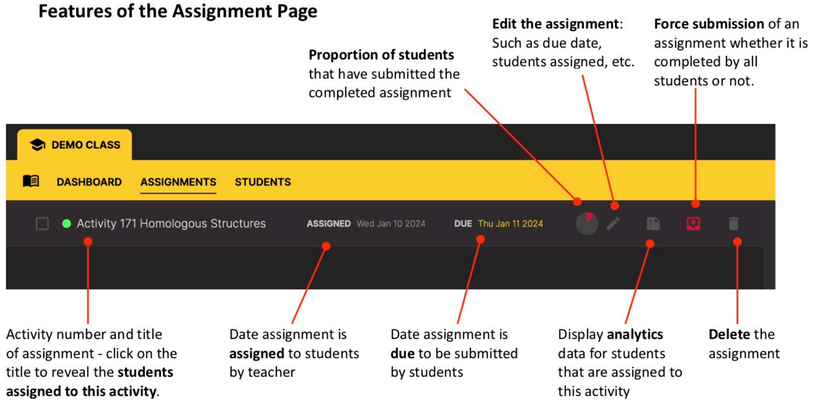
3. Set assignment details:
   (a) Name or simply use the default activity.
   (b) How many marks are to be assigned to this assignment (note this is optional, i.e. not graded).
   (c) Set submission date and time required by students.
   (d) Choose which class, or individual students are to be assigned.
   (e) Either save as a **DRAFT** or **PUBLISH**.



4. Once the assignment has been created, it will appear in the list of assignments (see below).
5. The teacher may edited various aspects of the assignment, such as dates and which students it is assigned to.

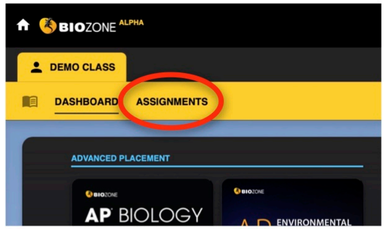
Watch a video showing this process:
https://vimeo.com/888549317

Features of the Assignment Page

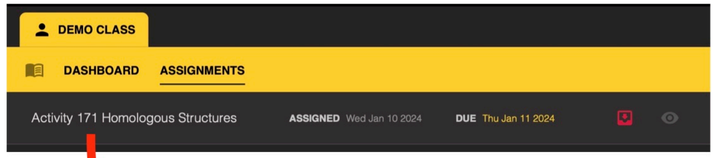


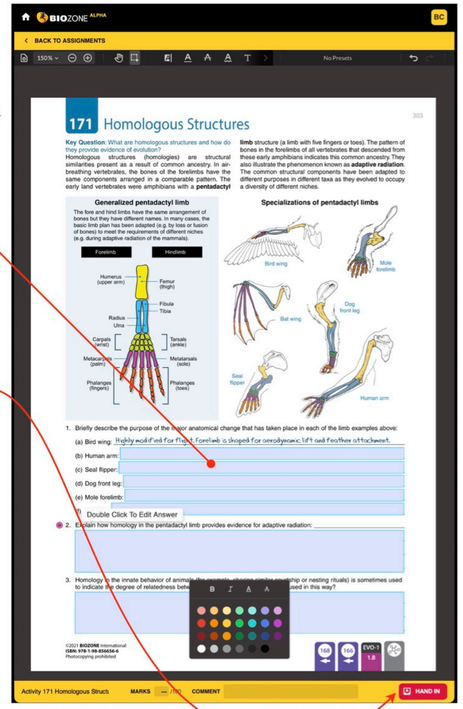
Student Answering an Assignment:

1. From the Dashboard (Home screen) student clicks on the **ASSIGNMENTS** menu to see current activities assigned to them.
   The display will now show all current activities assigned to the student for completion.



2. Click on the **Activity** assigned to begin working on the assignment.





3. Double-click into the answer boxes (pale blue) next to each question and type in your answers.

4. When you have entered answers, you may still go back and edit them until you click on the "**HAND IN**" button (bottom/right). This cannot be "undone" by the student, so take care to check your answers before submitting.

5. This will submit the student answers so the teacher assigned to the class can view and possibly grade the answers.

Watch a video showing this process:
https://vimeo.com/888549455

Teacher Grading an Assignment:

1. Click on the **assignment name** to see the entire list of students currently assigned the activity.
2. The list of students will show the status of their progress: whether they have submitted their assignment (or not), marks allocated (grading is optional), comment from the teacher.
3. Click on the "**EYE**" button to view individual student answers.

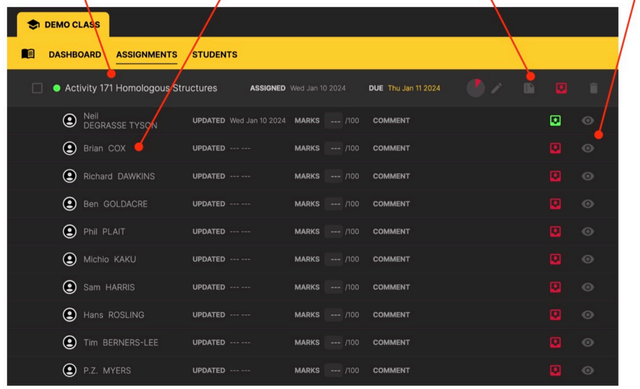
Watch a video showing this process:
https://vimeo.com/888549657

Click on the title to reveal the **students assigned to this activity** (already shown below)

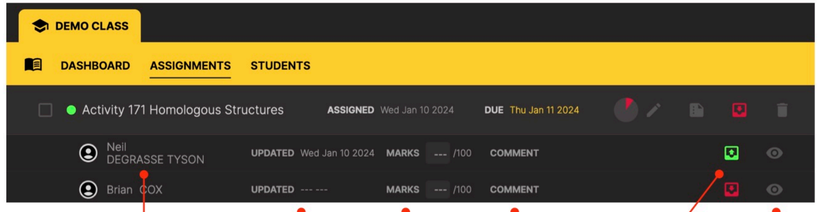
Student names are displayed with their status of whether assignment is submitted or not

Display **analytics** data for students that are assigned to this activity

View answers for each student by clicking on the "**EYE**" button



Enlarged View of Above:



Date assignment was **submitted** by student

Teacher's **comment** to the student

Click the "**EYE**" button to view individual student submissions

Student **identification**

Marks assigned to student for assignment as a whole
NOTE: No marks indicate that the teacher has not assigned grading

Color indicates whether the activity has been submitted by the student:
Green = submitted
Red = not submitted

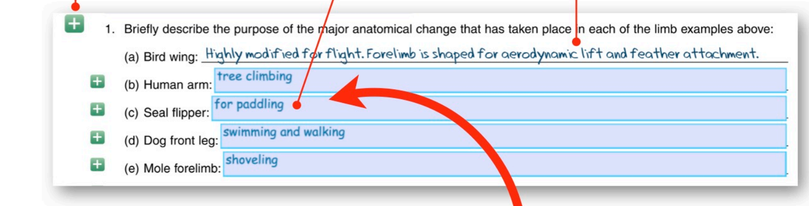
Teacher View of Student Answers

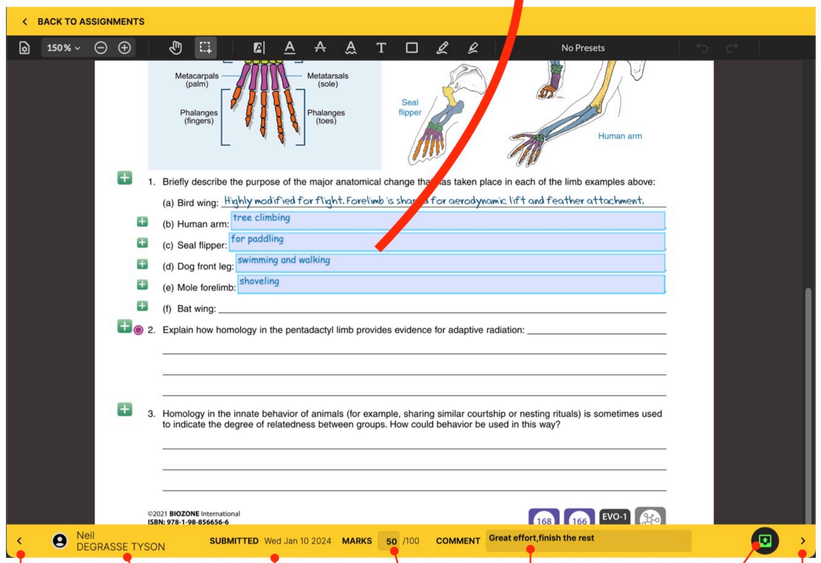
HINT: Use the **PREVIOUS** and **NEXT** buttons at the bottom of the page to move quickly between each student in the class, and see how each student answered the same questions.

Model answer show/hide display buttons

Student's answers are displayed in blue text boxes

Suggested **model answers** are displayed for teacher to see during the review/grading process





Click (<) to view **PREVIOUS** student submission

Student **identification**

Date assignment was **submitted** by student

Marks assigned to student for assignment as a whole
NOTE: Teacher can decide total marks to be assigned to the activity

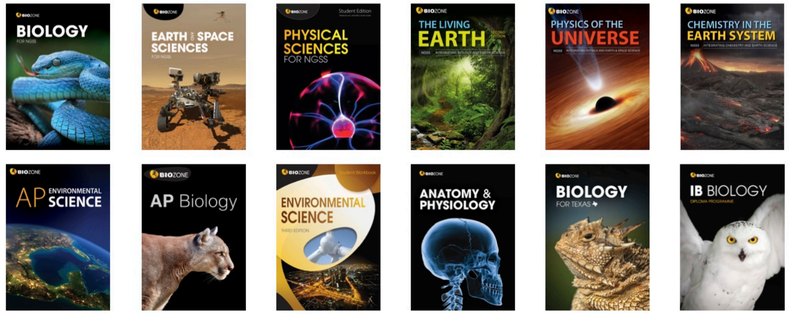
Teacher's **comment** to the student

Hand back the activity to the student (unlock the assignment) to redo their work, with a new submission date

Click (>) to view **NEXT** student submission

Programs Available on BIOZONE WORLD

UNITED STATES



INTERNATIONAL

AUSTRALIA

NEW ZEALAND

BIOZONE

Virtual Science Lab


Periodic Table of Elements
Centrifuge
EXIT


ments
Homework Assignment
BIOZONE's The Living Earth Activity 37
to be completed by Tuesday
ethan
alizarin
THE
RED
Safety Glasses
Volumetric Pipettes 25ml


THE CHEMISTRY OF FIREWORK COLOURS

BIOZONE

Virtual Science Lab:

Orientation

Teacher Notes:

Overview: Designed to introduce high school students to a well set up science laboratory and provide a fun orientation. The lab features a lot of equipment that would appear in chemistry lab, with other materials added for biology and earth sciences. There are also extra items of scientific apparatus that would normally only be found in a research lab or college lab (centrifuge, bioreactor, PCR thermal cycler machine).

Objectives: The game requires that the students become familiar with **health** and **safety hazards** and equipment. This requires them to do an "audit" to **identify risks** and become familiar with **safety equipment**, by discovering items in both categories. They will also learn the names of some of the more common (and exotic) lab equipment.

Student Instructions:

Welcome to the BIOZONE Science Lab orientation! This is an early look at an exciting project we are working on. Right now your interaction is limited to moving around and looking at things. In the future, we will allow you to have useful interactions with the equipment.

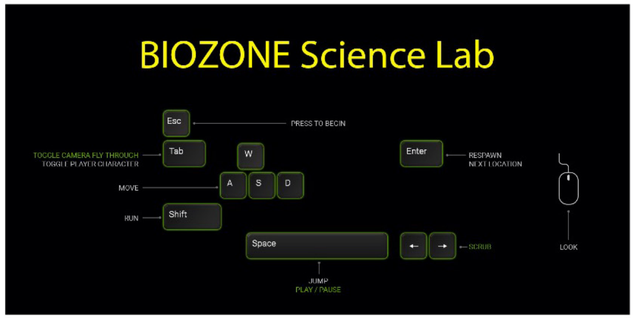
In this simulation, you can move around and look at the equipment and features of a modern school science lab. The lab features a lot of equipment that would appear in chemistry lab, with other materials added for biology and earth sciences. There are also extra items of scientific apparatus that would only be found in a research lab or college lab (bioreactor, PCR machine).

- Read the **Lab Rules** on the notice board in the Lab (next two the teacher's front bench)
- Can you spot **8 lab safety rules** being broken (HINT: look on bench tops as well as the floor)?
- Can you find up to 12 items of **safety equipment** that reduce or respond to hazards in the lab (HINT: look on bench tops, walls, ceiling, as well as the floor)?

NOTE: Please be patient while the simulation loads - it may take a few minutes (depending on the speed of your internet connection.

To experience the best graphics, speed and interaction, try downloading one of the App versions of the simulation for **Windows** or **Mac OS**:

BIOZONE SciLab VR 2023 - MacOSX 482MB
BIOZONE SciLab VR 2022 - Windows 332MB



Use the **arrow keys** or (**WASD**) to move and use the **mouse** to look around (look in different directions).

1. The player must carry out a **Health & Safety audit**:

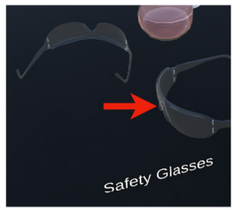
   (a) Read the **Lab Rules** on the notice board in the Lab (next two the teacher's front bench).

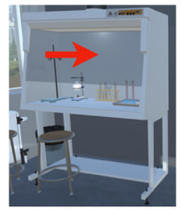
   (b) Identify and record (inventory) up the 8 health and safety **hazards** in the lab:

   1. Broken glass
   2. Spilled chemical on bench
   3. Water on the floor
   4. Scalpel blade near the edge of the bench
   5. Drink in the lab
   6. Food in the lab
   7. Bunsen burner too near the edge of the bench
   8. Petri dishes exposed with bacterial colonies

(c) Identify and record (inventory) on the 12 **mitigations** that ensure safety:

1. Fire extinguisher
2. Fire alarm
3. Fire blanket
4. First aid kit on the wall
5. Emergency EXIT sign
6. Safety glasses
7. Biohazard Waste bin
8. Fume cupboard for dangerous experiments that give of noxious gases
9. Safety tongs for handling hot test tubes
10. Smoke detector (ceiling)
11. Fire sprinkler system
12. Extractor fan duct over benches





BIOZONE
Virtual Science Lab

You will be able to access the experimental version in 3 ways:

- **Online** (browser) version
- **Windows** OS App version
- **Mac** OS App version

Let us know what you think :)