

Leeto le hlolang la

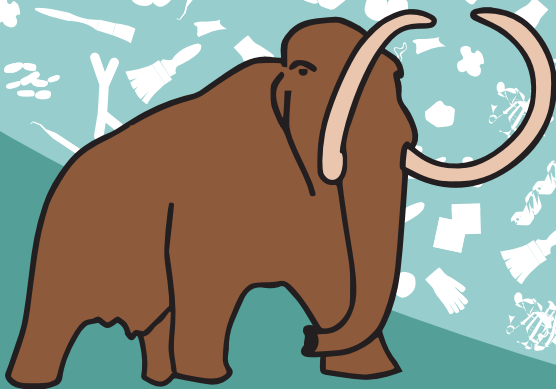
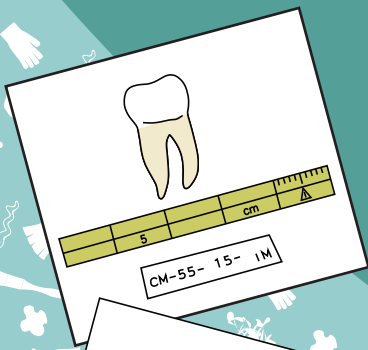
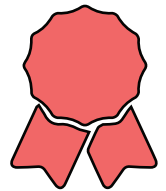
# MAHLALE A BOEPOLLI BA NALANE



Buka ena ke ea:

Lebitso

**Setsebi sa Mahlale a  
Boepolli ba Nalane, sa  
kamoso se thupelong**

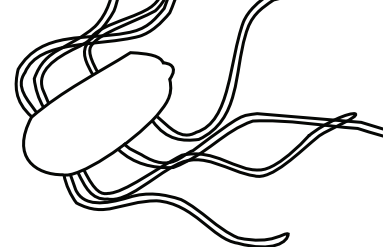


Buka ea botaki ka  
The Max Planck Institute for  
Evolutionary Anthropology



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# MAHLALE A BOEPOLLI BA NALANE



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**Setsebi sa Mahlale a  
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**Buka ea botaki ka**

The Max Planck Institute for  
Evolutionary Anthropology





**Mohatisi:** Max Planck Institute for Evolutionary Anthropology

**Mongoli:** Christina Warinner

**Motlatsi oa Mongoli:** Jessica Hendy

**Ba kentseng letsoho:**

Zandra Fagnäs

Jessica Hendy

Allison Mann

Åshild Vågene

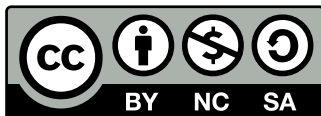
Ke Wang

Christina Warinner

**E fetoletsoe puong ea Sesotho ke:**

Ts'episo Seisa, Ithabeleng Mokoena le Nthabiseng Mokoena-Mokhathi

Buka ena ea botaki e hlahisitsoe e le karolo ea thupelo ea mahlale a ho tšoantšetsa.



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DOI: 10.17617/2.3372924  
2022



# BAO RE LENG BONA

Baepolli ba lintho tsa khale ba mahlale ke bafuputsi ba sebelisang mekhoa ea mahlale le litsebo tsa morao-rao ho araba lipotso tse mabapi le nalane ea batho.



Torofolo

## Sebakeng seo ho epolloang ho sona...

Litsebi tsa mahlale li sebetsa haufi-ufi le baepolli ba lintho tsa khale, ho epolla le ho bokella lihlahlobuoane hore ba ithute tsona ka har'a sebaka sa mahlale sa tlhahlobo.

Sena se ka akarelletsa ho hloaea mabitla, ho bokella masalla a fumanoang lipitseng tsa khale, ho sheba masapo a liphoofole lithotobolong, kapa ho sefa mobu bakeng sa ho fumana limela tsa boholo-holo.

## Ka har'a sebaka sa mahlale sa tlhahlobo...

Ha li tsoara phatsa ea lefutso ea khale (*ancient DNA*), litsebi tsa mahlale li tlameha ho sebelletsa sebakeng se hloekileng, li apere liaparo tse khethehileng, liatlana le likhohlopo ho sireletsa lihlahlobuoane tsa khale hore li se ke tsa hahlameloane ke phatsa ea lefutso (DNA) ea morao-rao.

Litsebi tsa mahlale li sebelisa lisebelisoa tsa mofuta-futa le thepa ho ithuta lihlahlobuoane tsa khale.



Peipi ea mahlale





# HO EPOLLA SEBAKENG SE HLOATLOENG

Baepolli ba lintho tsa khale ba mahlale ba etela linaheng tsohle lefatšeng ho batlisisa nalane ea batho, ekaba pele nalane eo eka ngoloa fatše kapa ha e se e ngotsoe. Ho tlatselletsisa lisebelisoa tsa boepolli, libakeng tse ling ho hloka-hala thepa e khethehileng. Ka mohlala, lithabeng tsa Himalayas, baepolli ba lintho tsa khale ba hloka mangolo a tumello ea ho hloahloaila le thepa ea ho hloa lithaba.

Dep...  
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accordance with the rule 33 of...  
the permission is to be...  
in the area of Mustang...  
District (except...  
to 19...

**NATIONAL TRUST FOR NATURE CONSERVATION**  
Entry Permit (ACAMCA/GCA)  
Schedule - 2 (Relating to Sub-Rule (1) of Rule 19)

Receipt No. **0281630**

Entry Permit No. \_\_\_\_\_

Full Name: \_\_\_\_\_

Date of Birth: \_\_\_\_\_

Passport No. \_\_\_\_\_

Nationality: \_\_\_\_\_

Purpose of Visit: \_\_\_\_\_

Date: \_\_\_\_\_

Entry Permit Issuing Authority: \_\_\_\_\_

Signature: \_\_\_\_\_

Full Name: \_\_\_\_\_

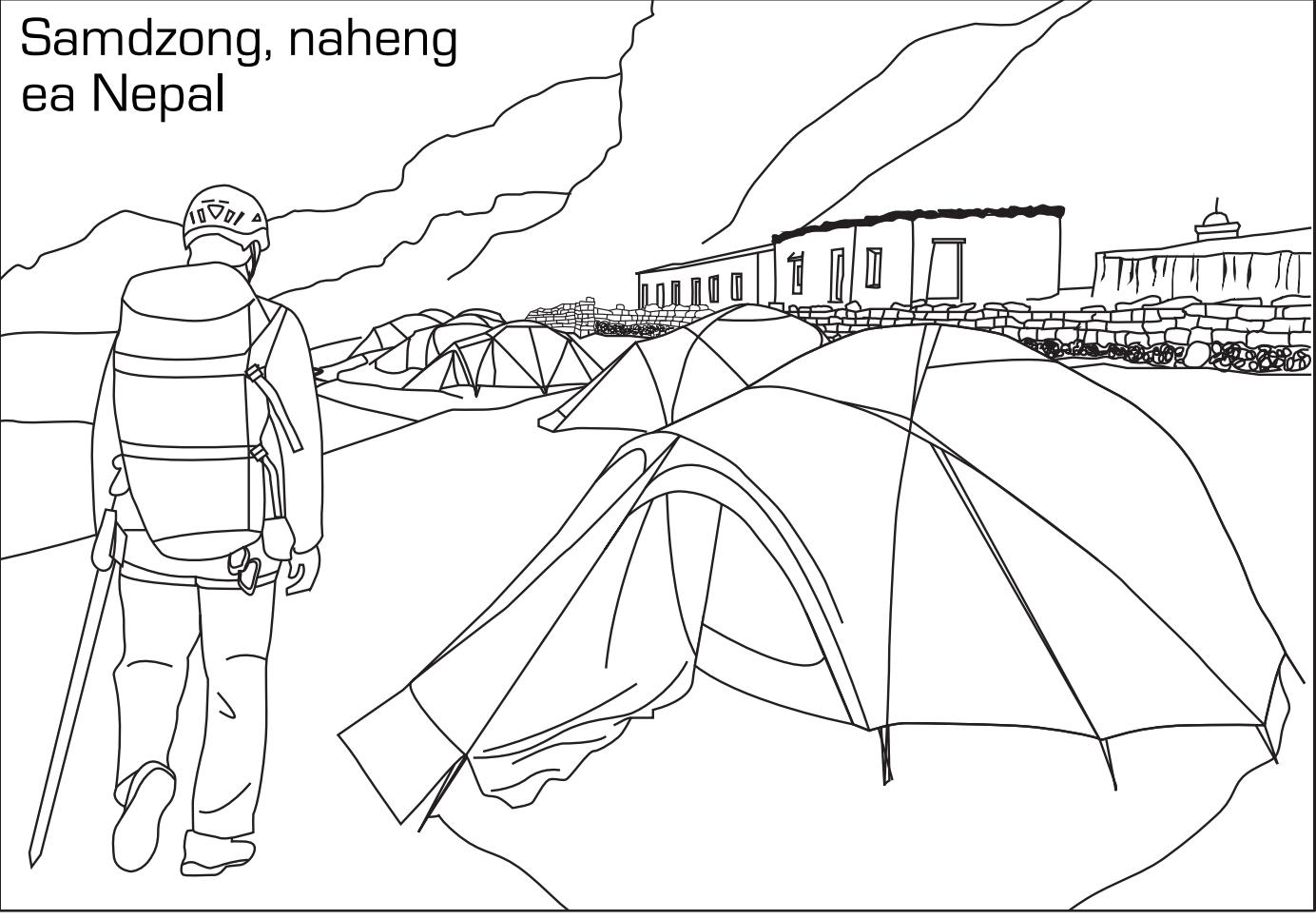
Designation: \_\_\_\_\_

**NATIONAL TRUST FOR NATURE CONSERVATION**  
NTNC-ACAMCA  
Entry Fee Receipt  
Ticket No. **0281630**  
Date \_\_\_\_\_  
Received by \_\_\_\_\_  
Nationality \_\_\_\_\_  
Authorized Signatory: **SHERPA SHAIKUN-LA**

**TOURIST COPY**

gration Officer  
da No

## Samdzong, naheng ea Nepal





## Bokh'okh'o bo menong

Bo ka bitsoa litšila tse bakoang ke lijo, bokh'okh'o bo menong ke karolo feela ea 'mele oa hao e ipopang ha u ntse u phela. Bo tsoasa lijo le baktheria, bo ka sebelisoa ho aha nalane ea boemo ba bophelo ba motho ha a ntse a phela le mokhoa oa ho ja.

## Masapo le Meno

Masapo le meno a fupere masalla a phatsa ea lefutso (DNA) a ka sebelisoa ho latellisa ho falla ha batho ba boholo-holo le ho re bolella ka litšobotsi tsa batho ba khale, tse ka reng 'mala oa moriri le 'mala oa mahlo a bona hape re ka ra tseba ka ho tloaelana le maemo a sebaka hoa batho ba khale. Meno a mahlasipa a lioa a ka fupara phatsa ea lefutso (DNA) ea kokoana-hloko eo e ba tšoaletseng.

## Masalla a lijo lipitseng tsa letsopa

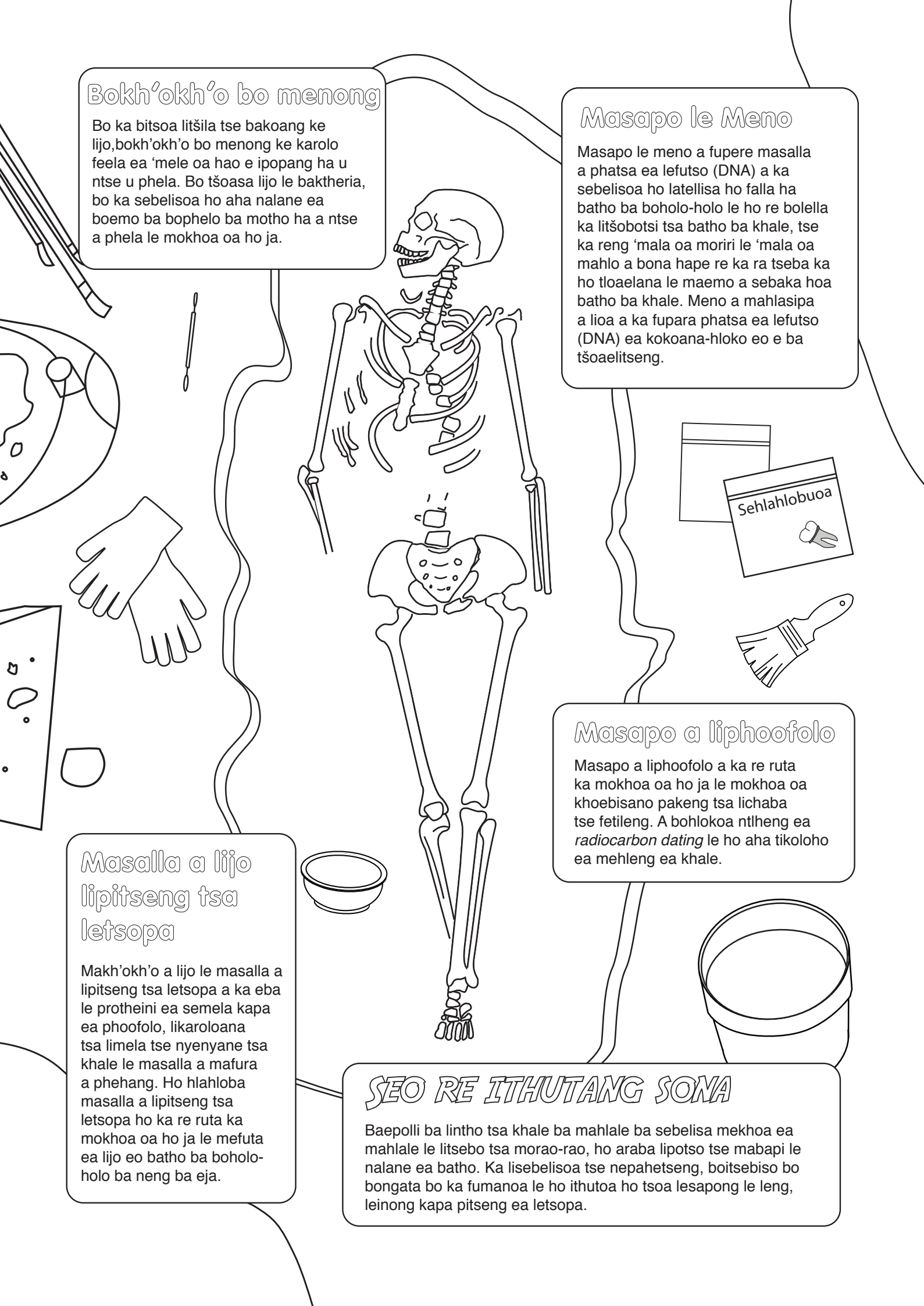
Makh'okh'o a lijo le masalla a lipitseng tsa letsopa a ka eba le protheini ea semela kapa ea phoofolo, likaroloana tsa limela tse nyenyane tsa khale le masalla a mafura a phehang. Ho hlahloba masalla a lipitseng tsa letsopa ho ka re ruta ka mokhoa oa ho ja le mefuta ea lijo eo batho ba boholo-holo ba neng ba eja.

## SEO RE ITHUTANG SONA

Baepolli ba lintho tsa khale ba mahlale ba sebelisa mekhhoa ea mahlale le litsebo tsa morao-rao, ho araba lipotso tse mabapi le nalane ea batho. Ka lisebelisoa tse nepahetseng, boitsebiso bo bongata bo ka fumanoa le ho ithutoa ho tsoa lesapong le leng, leinong kapa pitseng ea letsopa.

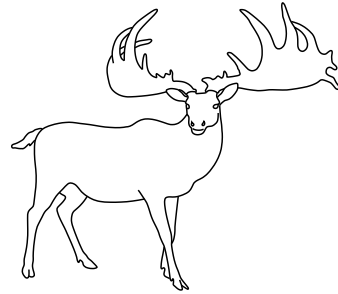
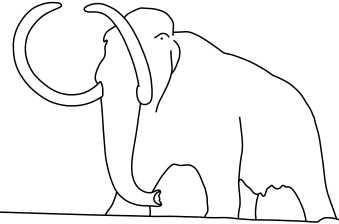
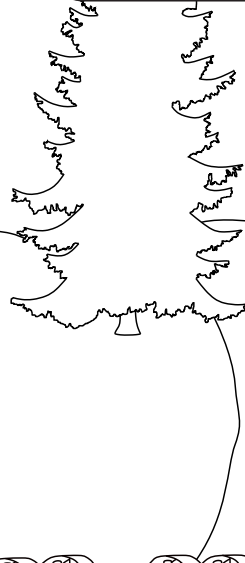
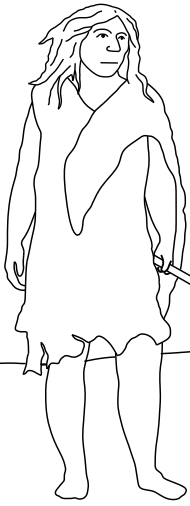
## Masapo a liphoofole

Masapo a liphoofole a ka re ruta ka mokhoa oa ho ja le mokhoa oa khoebisano pakeng tsa lichaba tse fetileng. A bohlokoa ntlheng ea *radiocarbon dating* le ho aha tikoloho ea mehleng ea khale.



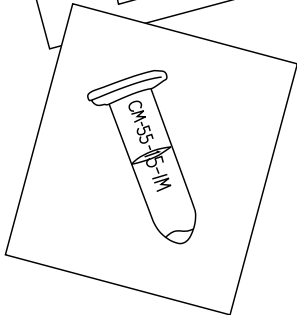
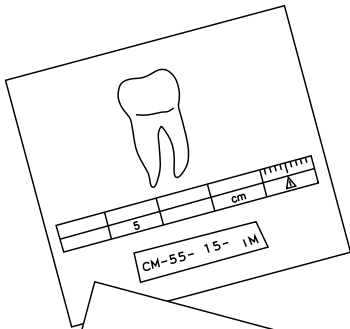
## NA U NE U TSEBA?

Maneanderthale a ile a shoa lilemong tse ekabang 40,000, empa phatsa ea lefutso (DNA) ea bona e ntse e phela haholo-holo ho batho bao eseng Maafrica kajeno.



## NALANE EA BATHO

Phatsa ea lefutso ea khale (*ancient DNA*) e re thusa ho utloisisa bo-motsoala ba rona: Maneanderthale.



## Phetoho

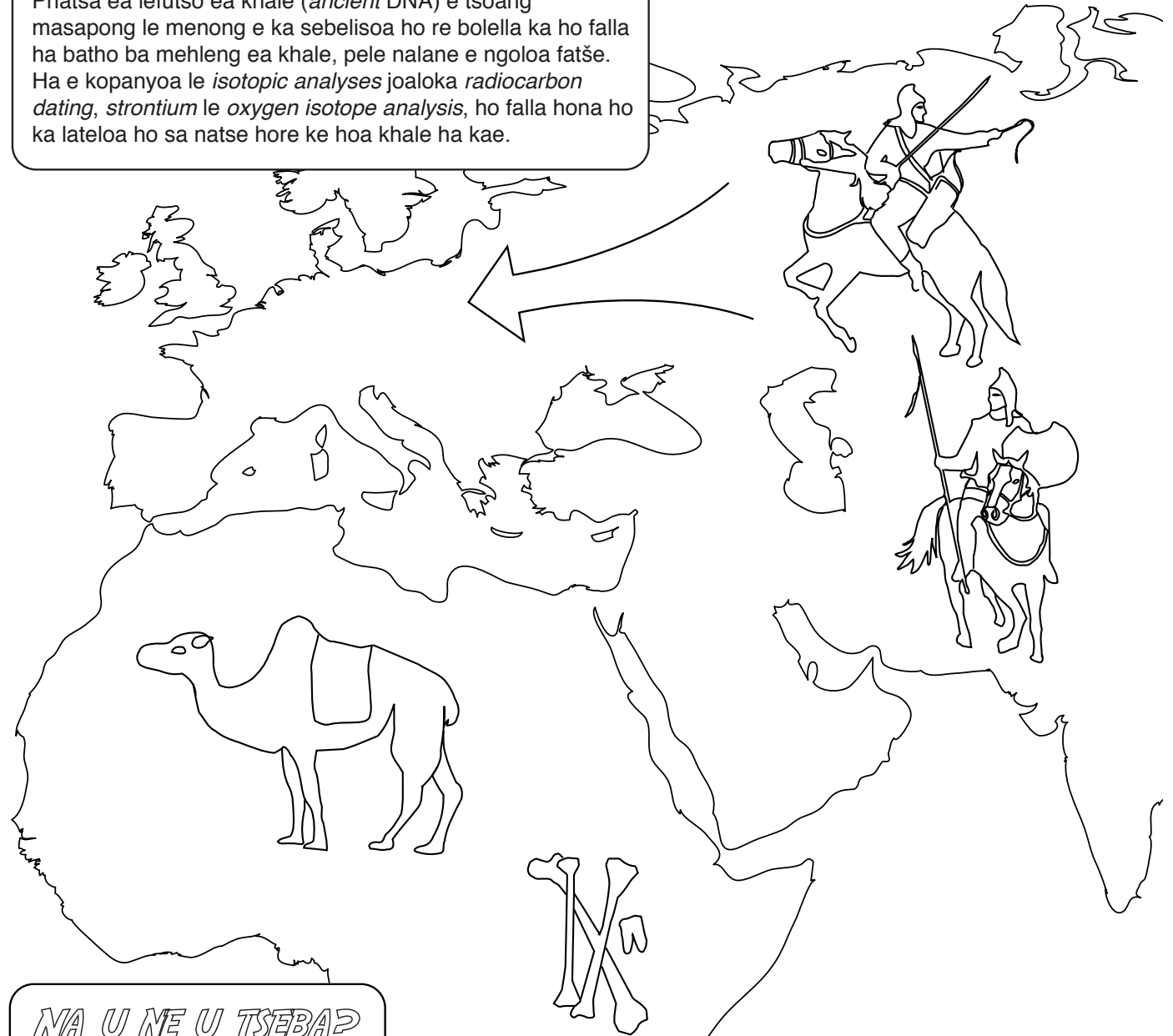
Ka ho ithuta meno le masapo a batho ba phetseng khale, re ka rua tsebo ka tsela eo baholo-holo ba rona ba neng ba phela ka eona, le hore sena se bile le tšusumetso ho rona joang kajeno.



# HO FALLA HOA KHALE

Phatsa ea lefutso ea khale (*ancient DNA*) e tsoang masapong le menong e ka sebelisoa ho re bolella ka ho falla ha batho ba mehleng ea khale, pele nalane e ngoloa fatše. Ha e kopanyoa le *isotopic analyses* joaloka *radiocarbon dating*, *strontium* le *oxygen isotope analysis*, ho falla hona ho ka lateloa ho sa natse hore ke hoa khale ha kae.

## Baskitha, Asia Bohareng Mehlang ea Tšepe, 700 BC



# NA U NE U TSEBA?

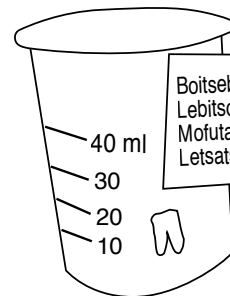
*Radiocarbon* kapa *carbon-14* ke *isotope* e sa tsitsang ea *carbon*, e tsoang moeeng, e monyoya ke limela nakong ea *photosynthesis*. Liphoofole li kenya *radiocarbon* 'meleng ea tsona ha li ja limela.

*Radiocarbon* ea fela ha nako e ntse e feta.

Ka ho nka palo ea *carbon-14* e ntseng e le teng ho sehlahlobuoa sa khale, hoa khonahala ho hakanya hore phoofole kapa semela seo se phetse neng.



## Radiocarbon dating



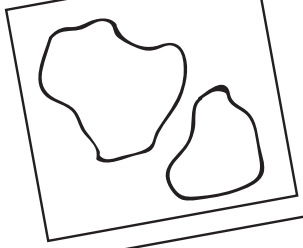
Boitsebiso ba sehlahlobuoa:  
Lebitso la mosebetsi:  
Mofuta oa sehlahlobuoa:  
Letsatsi:

*Radiocarbon dating* ke mokhoa o sebelisoang ho hakanya lilemo tsa liphoofole le limela tse phetseng lilemong tse ka bang 40,000 tse fetileng.

# MOKHOA OA HO JA OA BOHOLO-HOLO

Litsebi tsa mahlale li sebelisa li-*microscope* ho fumana likaroloana tse nyenyane tsa lijo lipitseng tsa khale le menong a batho. Ho hlahlobisa "li-*microfossil*" tse, ho re rutile ka lijo tse neng li jeoa ke Bamaya ba boholo-holo ba phetseng *Mesoamerica* lilemo tse 2000 tse fetileng.

Copan, naheng ea Honduras  
Maya ea boholo-holo,  
selemo sa 300



COP-4

Lisele tsa poone

Leqhetso la peo

Phofshoana ea semela

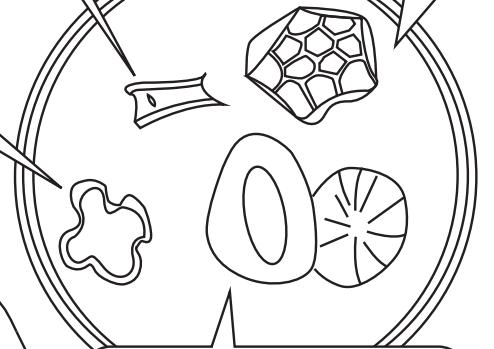
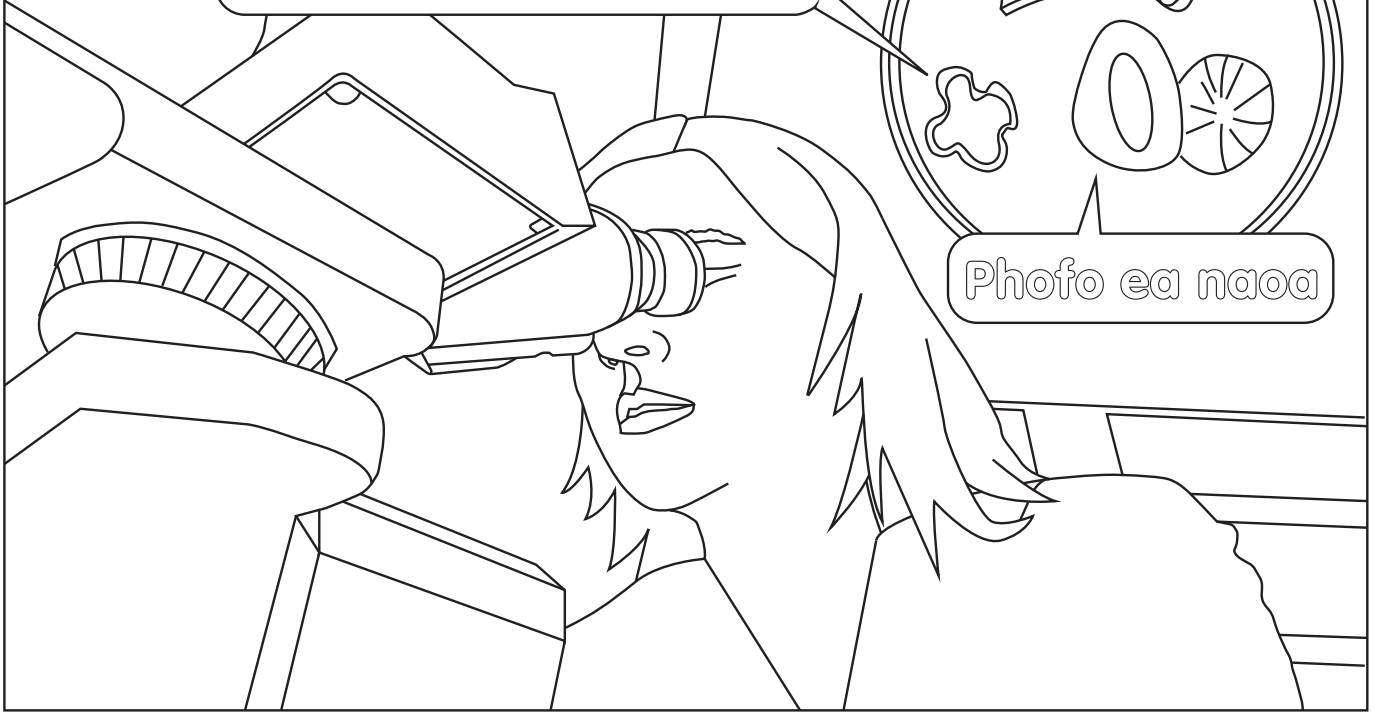


Photo ea naoa

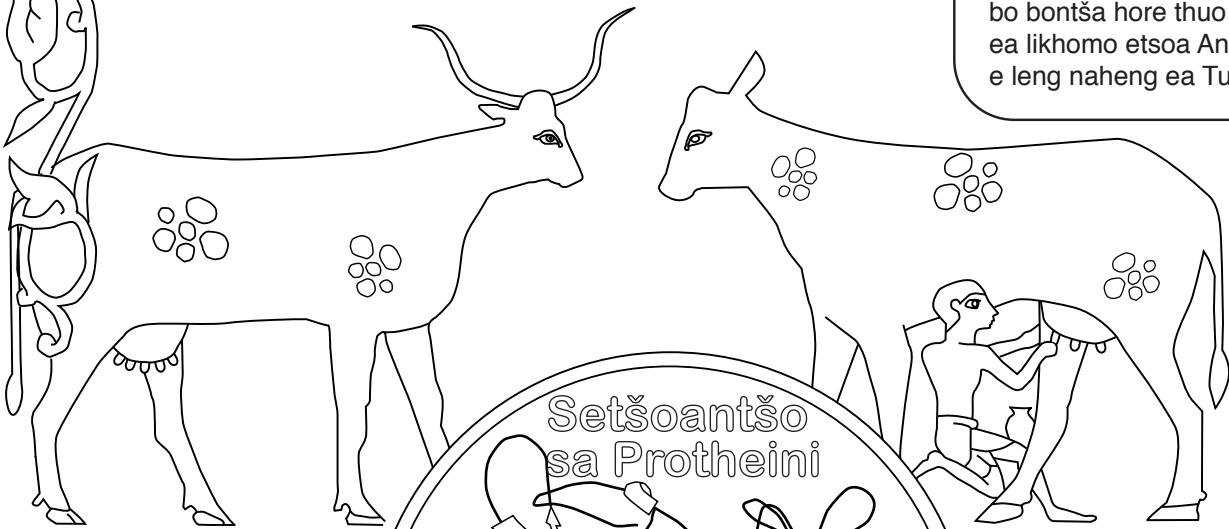


# THUO

E se e le lilemo tse fetang 10,000 joale batho ba khetha mefuta ea limela le liphoofole bakeng sa ho li rua. Likhomo ke tse ling tsa pele har'a liphoofole tse jeoang tseo batho ba qalileng ho li rua, batho ba khale ba ne ba li sebelisa bakeng sa ho hula thepa, nama, lebese le makoko.

# NA U NE U TSEBA?

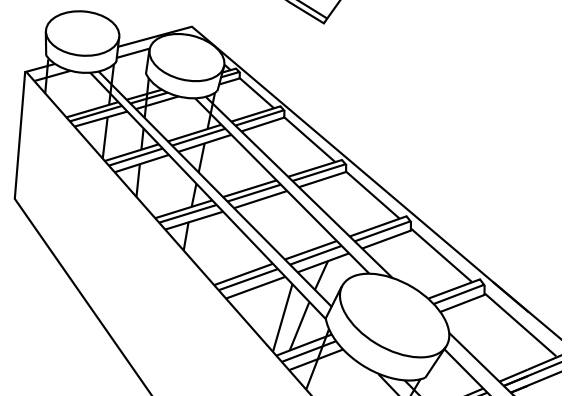
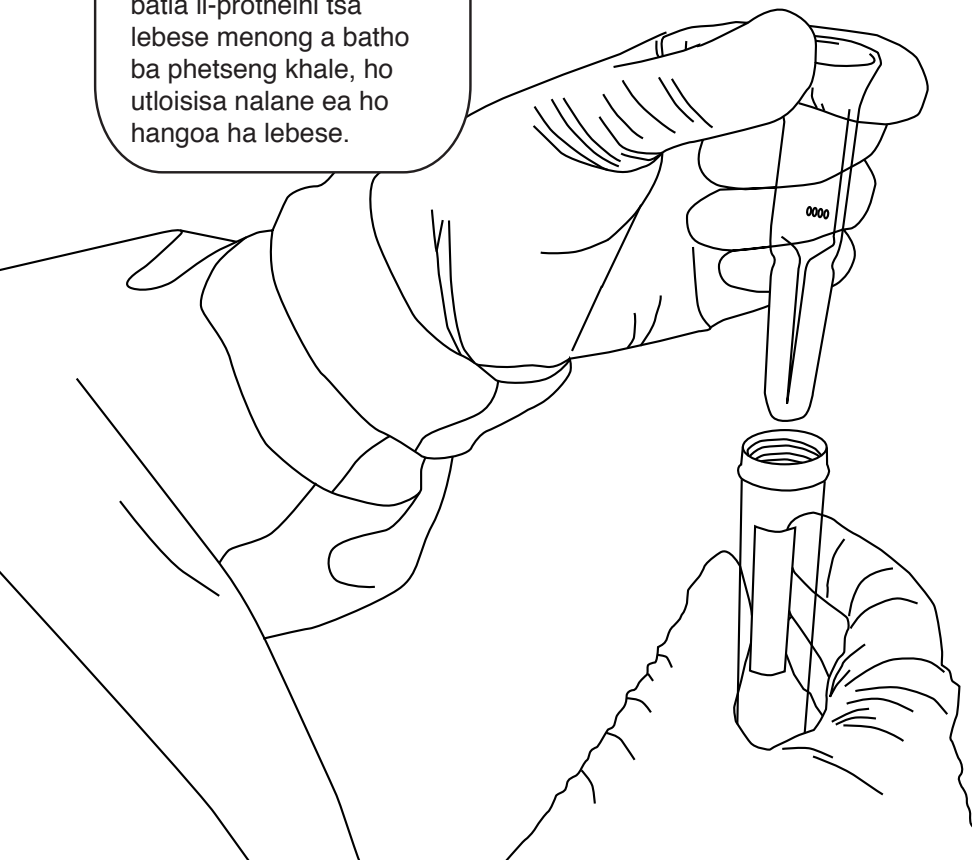
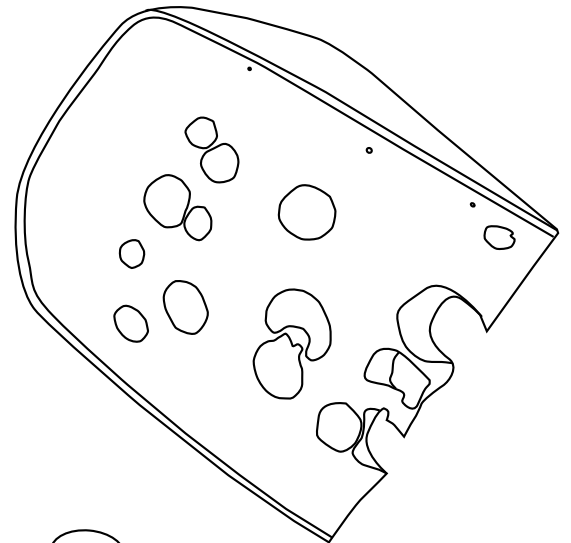
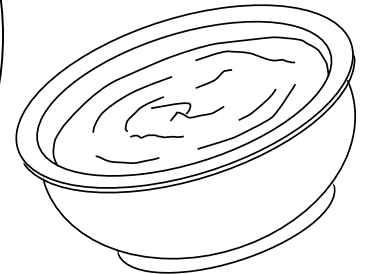
Likhomo tsa pele tsa ho ruoa, e ne e le li-*auroch* tseo e neng e le likhomo tse kholo tse hlaha, tse seng li sa phele hona joale. Bopaki bo bontša hore thuo ea pele ea likhomo etsoa Anatholia, e leng naheng ea Turkey.



## Setšoantšo sa Protheini

### Tšimoloho ea lihlahisoa tsa lebese

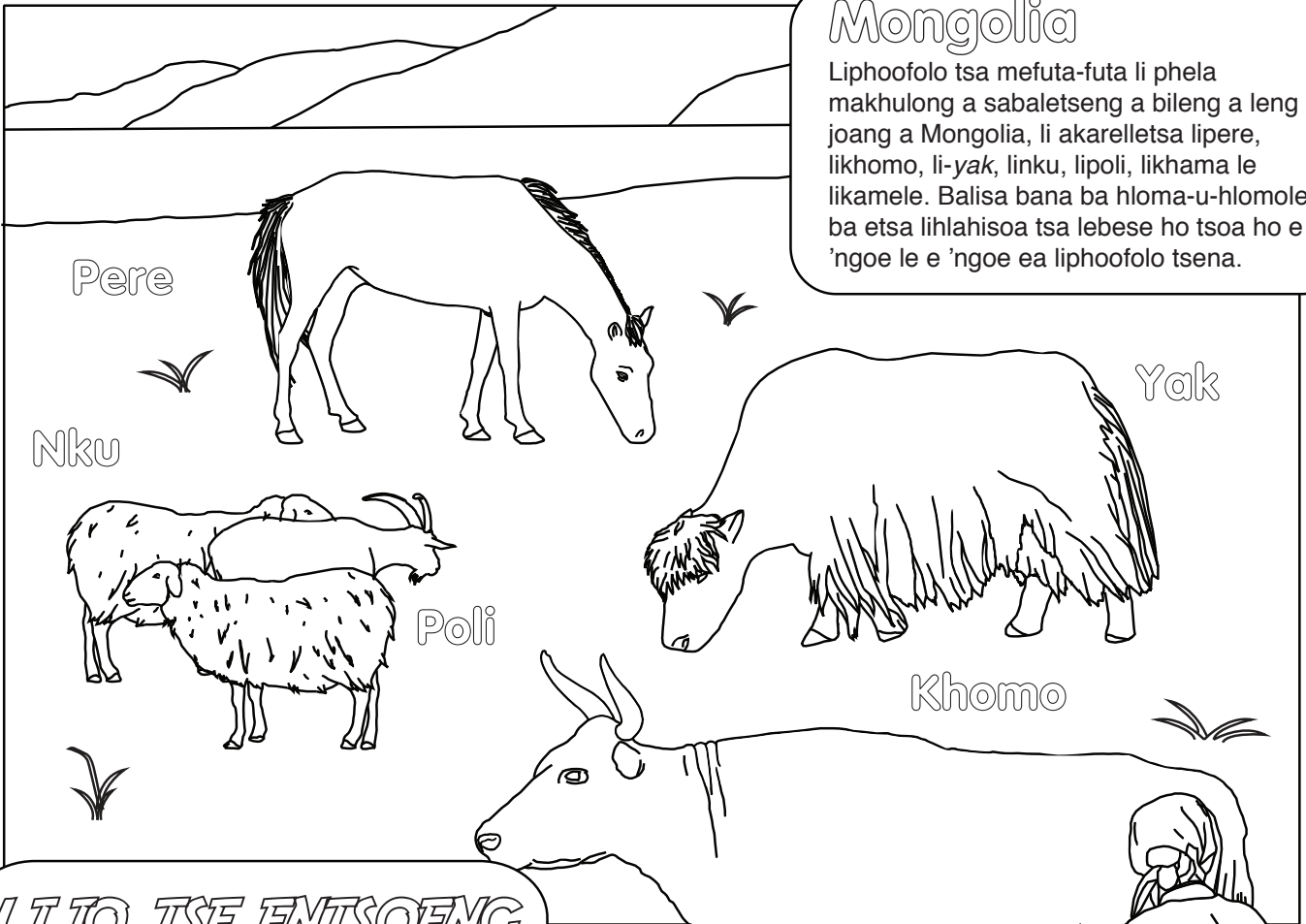
Tšimoloho ea lihlahisoa tsa lebese ha e tsebahale hantle, feela baepoli ba lintho tsa khale ba mahlale, ba sebelisa mokhoa o bitsoang *mass spectrometry* ho batla li-protheini tsa lebese menong a batho ba phetseng khale, ho utloisisa nalane ea ho hangoa ha lebese.





# Mongolia

Liphoofolo tsa mefuta-futa li phela makhulong a sabaletseng a bileng a leng joang a Mongolia, li akarelletsa lipere, likhomo, li-yak, linku, lipoli, likhama le likamele. Balisa bana ba hloma-u-hlomole ba etsa lihlahisoa tsa lebese ho tsoa ho e 'ngoe le e 'ngoe ea liphoofolo tsena.



Pere

Nku

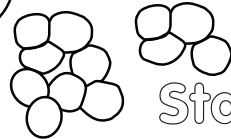
Poli

Yak

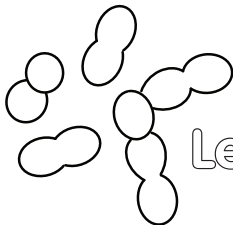
Khomo

## LIJO TSE ENTSOENG KA LEBESE

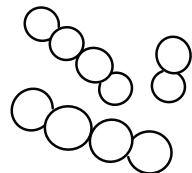
Lijo tse entsoeng ka lebese ke karolo ea bohlokoa ea bophelo ba letsatsi le letsatsi naheng ea Mongolia. Ho tsoa ho lipatlisiso tsa boepolli, re tseba hore moetlo ona o ka lebisoa bonyane ho lilemo tse 3,500 tse fetileng.



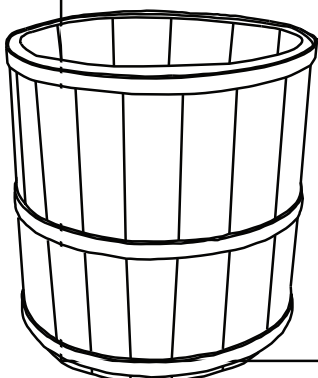
Staphylococcus



Leuconostoc

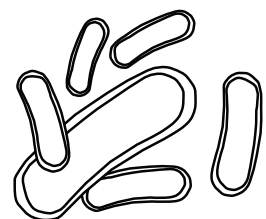


Lactococcus



## Likokoana-hloko tse sebelisoang lebeseng

Likokoana-hloko- haholo-holo baktheria le li-yeast- li bapala karolo e kholo ho etseng mefuta e fapaneng ea lihlahisoa tsa lebese joaloka *yoghurt*, botoro le *cheese* le tse ling tsa lijo tse sa tloaelehang tse kareng *airag* (likuku tsa mafi a omisitsoeng) le *airag* (joala ba lebese la pere).



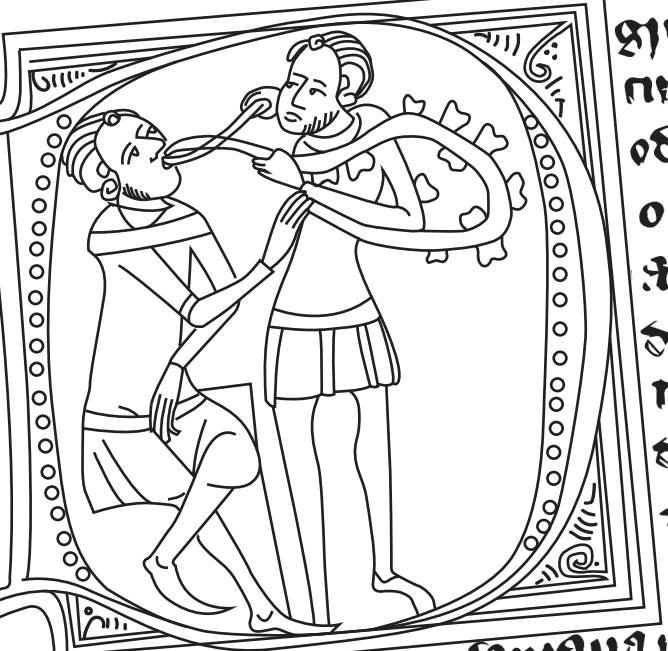
Lactobacillus

omni hilantia... sanctaie: qui totum

# MAFU A BOHOLO-HOLO

Masapo, meno le *tartar*-e leng litšila tsa meno tseo ha nako e ntse e feta li fetohang bokh'okh'o bo thata menong- a boloka boitsebiso ba bohlokoa ka boemo ba bophelo ba batho ba nako e fetileng. Ka mohlala, phatsa ea lefutso (DNA) le li-protheini tse bolokehileng litšileng tse na tsa meno, li thusa litsebi tsa mahlale ho utloisisa nalane ea lefu la marenene le ho bola ha meno.

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demby p Garthm de p... li: qm...



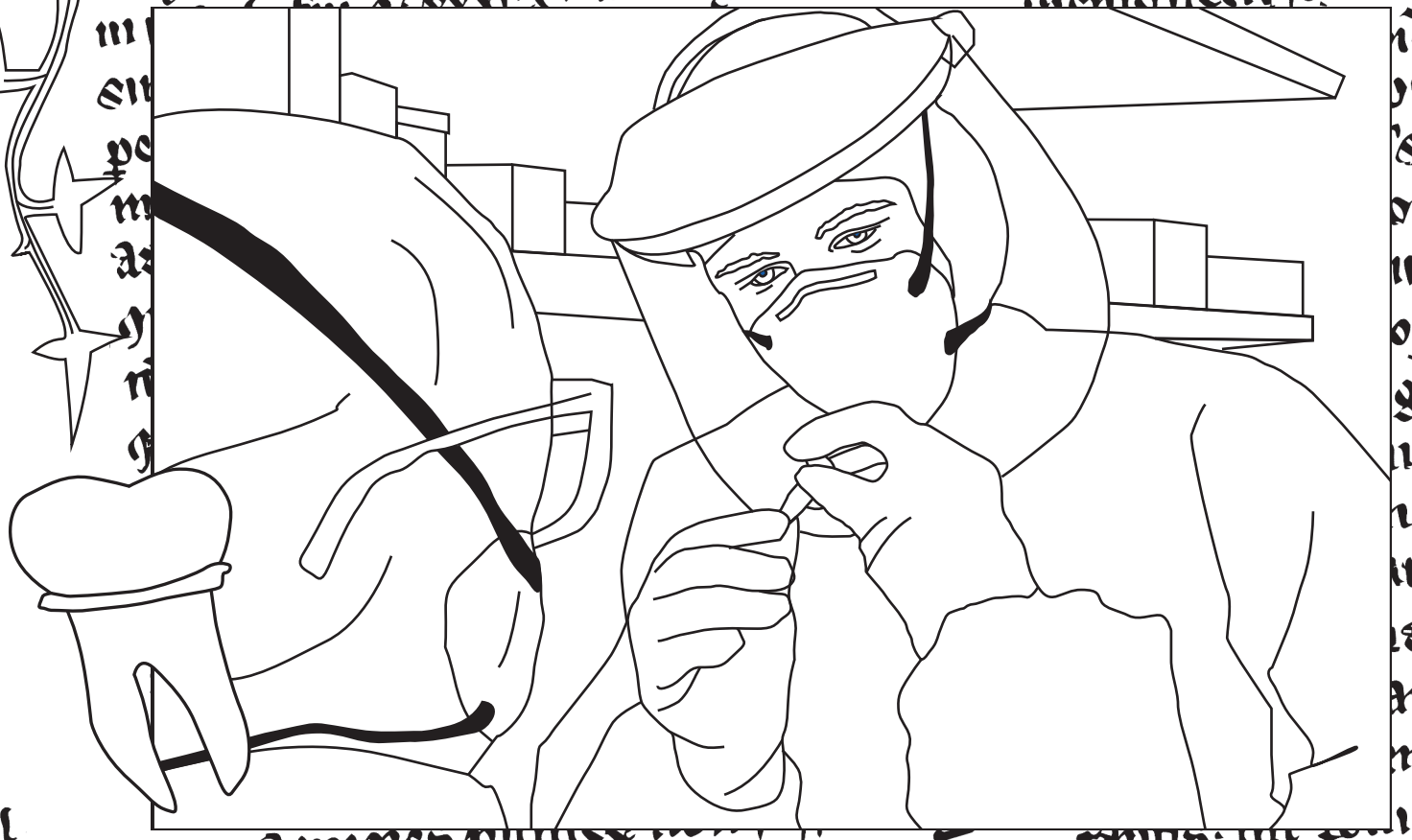
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### Omne Bonum

*Omne Bonum* ke *encyclopedia* ea Selatini ea lilemo tsa bo-1300, e ngotse litaba tsa bophelo ba Maeurope Mehlang e Bohareng ea lilemo (*Middle Ages*), e fumaneha *British Library*. E akarelletsa lethathamo la tlhokomelo ea meno le tlhokomelo ea bongaka tse re thusang ho utloisisa betere litaba tsa bophelo le mafu a Mehlang e Bohareng ea lilemo.

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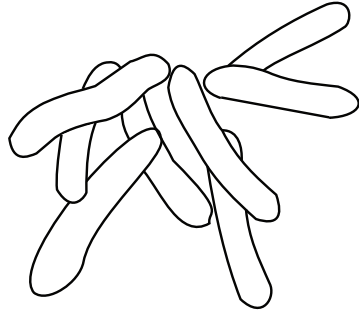
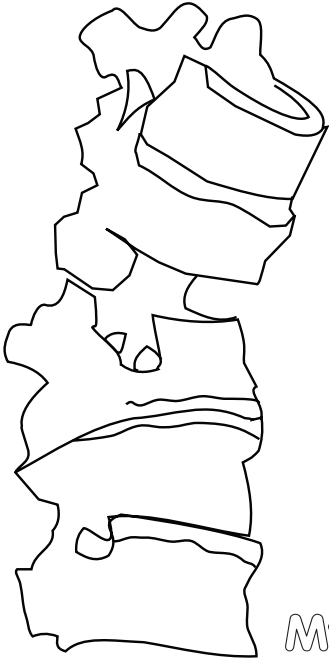


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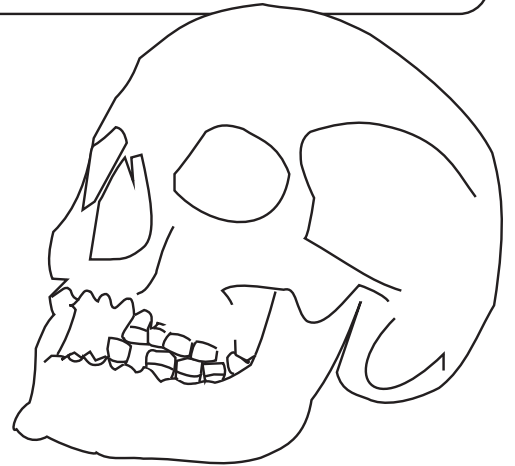
tantis...  
a dulcora sup me

## LEFUBA LE LEPERA

Lefuba le lepera li bakoa ke li-baktheria tse amanang: *Mycobacterium tuberculosis* le *Mycobacterium leprae*. Ka bobeli li ka tšoaetsa masapo, 'me masalla a phatsa ea lefutso (DNA) masapong a motho ea hlokehetseng a thusa litsebi tsa mahlale ho utloisisa nalane ea mafu ana a boholo-holo.

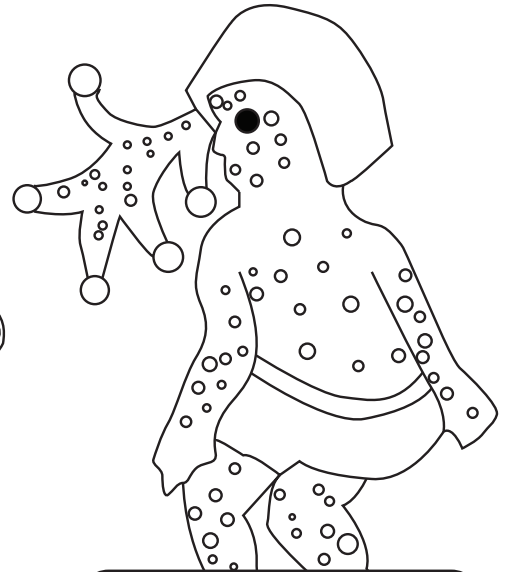


*Mycobacterium leprae*

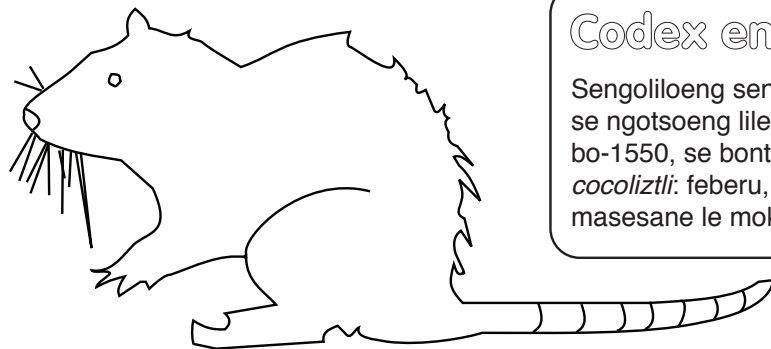
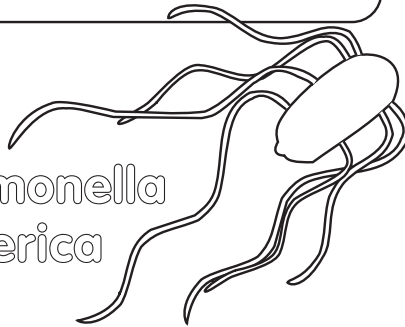


## COCOLIZTLI

Lefu le sa tsebahaleng-le ileng la bitsoa *cocoliztli* ke Maaztec- le ile la bolaea 60-90% ea sechaba sa naha ea Mexico pakeng tsa lilemo tsa 1545 le 1550. Haufinyane, phatsa ea lefutso (DNA) e tsoang ho kokoana-hloko e bitsoang *Salmonella enterica Paratyphi C* e ile ea fumanoa menong a mahlasipa a lefu lena.



*Salmonella enterica*



## Codex en Cruz

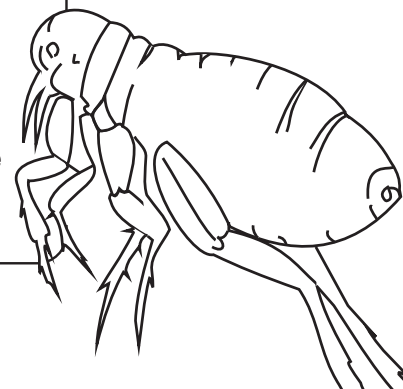
Sengoliloeng sena sa Maaztec se ngotsoeng lilemong tsa bo-1550, se bontša matšoafo a *cocoliztli*: feberu, makhopho a masesane le mokola.

## Dr. Schnabel

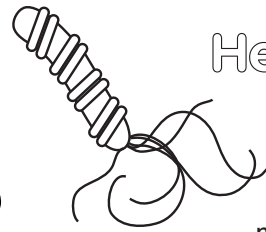
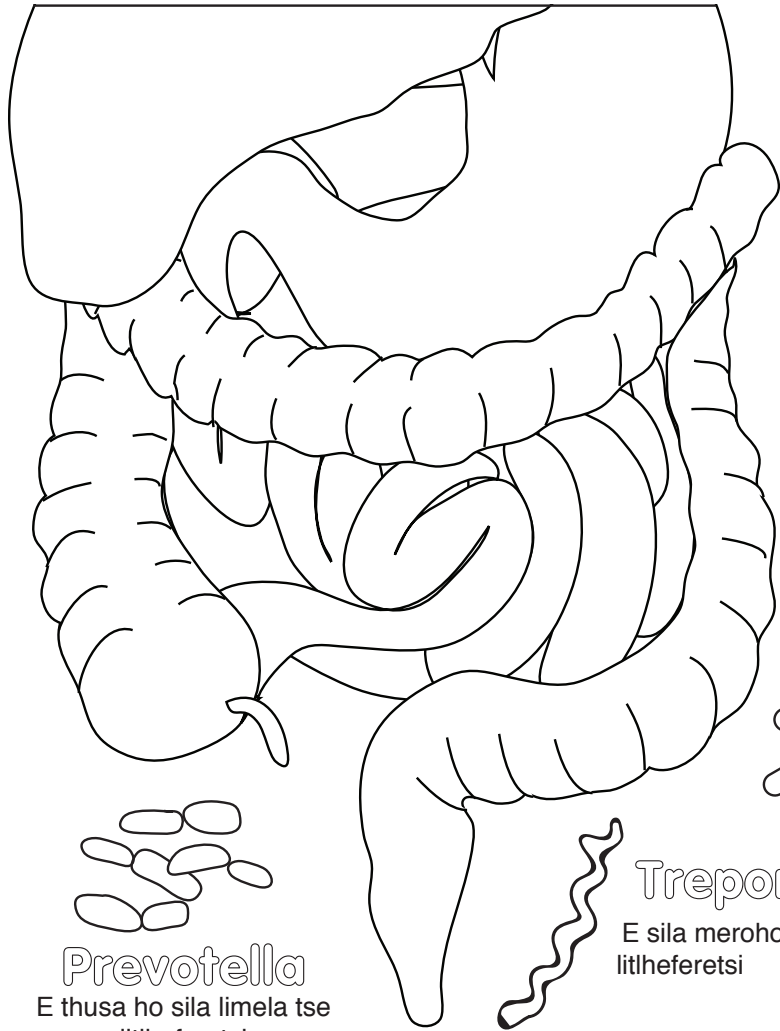
Lingaka tse neng li alafa bakuli ba seoa lilemong tsa bo-1600, li ne li roala limonkoana tse tšoanang le linonyana ka moetso ho li sireletsa ho "moea o mobe".

## LEFU LA SEOA

Lefu la Seoa le bakoa ke baktheria e bitsoang *Yersinia pestis*, e atang ka ho tšoaetsa matsetse a phelang likhotong. Batho ba longoang ke matsetse ana ba ruuha litšoelesa. Seoa sena e ne e le sesosa sa *Black Death* (1346-1353 mehleng ea rona) eo ileng ea bolaea motho a le mong ho ba babeli Europe.







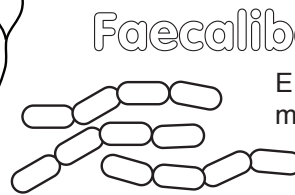
Helicobacter  
pylori

E phela ka mpeng e  
ka baka liso tsa mala le  
mefuta e meng ea mofetše



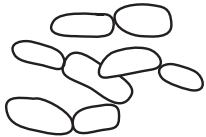
Bifidobacterium

E thusa masea ho monya  
lebase 'meleng



Faecalibacterium

E etsetsa lisele tsa  
mala lijo



Prevotella

E thusa ho sila limela tse  
lithheferetsi

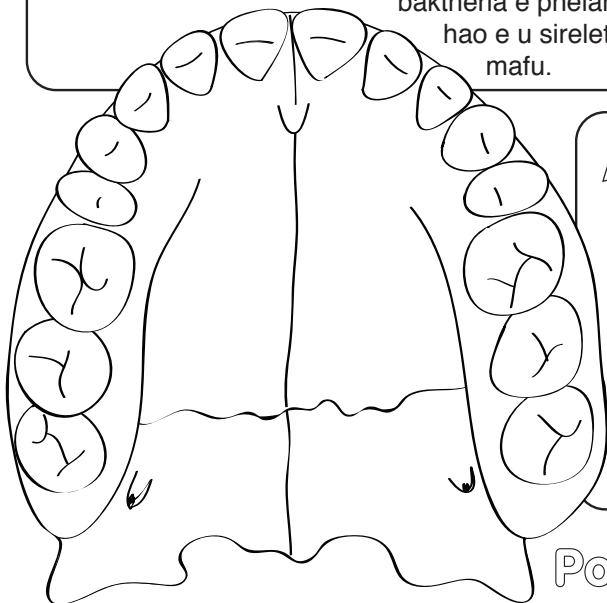


Treponema

E sila meroho le  
lithheferetsi

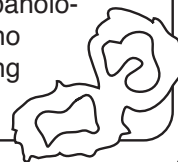
## MICROBIOME EA BAHOLO-HOLO BA RONA

'Mele oa hao ke lehae la lisele tse **likete-kete** tsa baktheria, 'me hammoho li bitsoa *microbiome*. Baktheria e phelang ka maleng a hao e u thusa ho sila lijo le ho matlafatsa sesole sa hao sa 'mele. Baktheria e letlalong la hao e thusa ho hloekisa letlalo la hao, baktheria e phelang ka lehanong la hao e u sireletsa khahlanong le mafu.

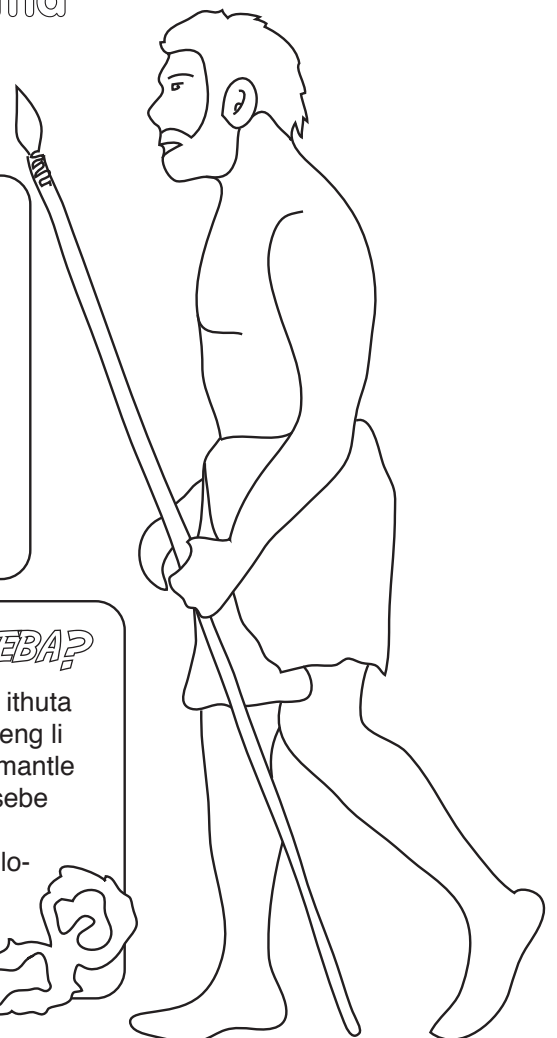


### NA U NE U TSEBA?

Litsebi tsa mahlale li ithuta litšila tsa meno tse seng li entse bokh'okh'o le mantle a khale e le hore li tsebe haholoanyane ka *microbiome* ea baholo-holo ba rona le ho tseba hore ke eng e bakang mafu.



Porphyromonas

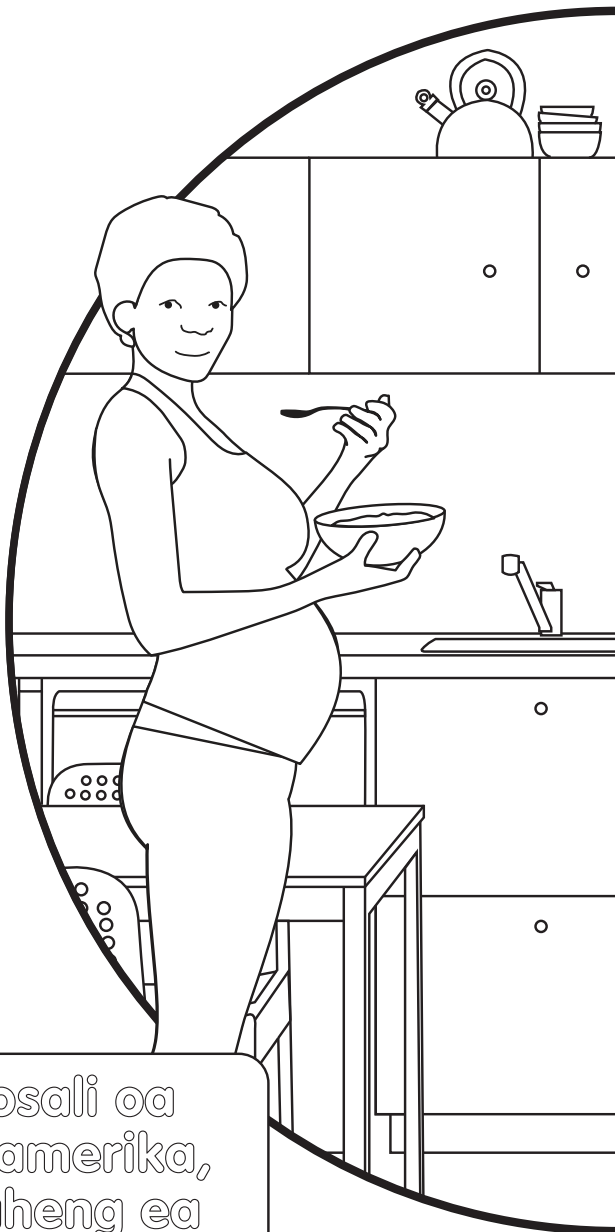


# LITSOMI

Litsomi li ja limela tsa naha le liphoofole tse hlaha, 'me mokhoa oa tsona oa ho ja o itšetlehile ka hore ke nako e fe ea selemo.

Pele ho qaloa ho lengoa ho ekabang lilemo tse 10,000 tse fetileng, batho bohle lefatšeng e ne e le litsomi.

Batho ba tsohang kajeno ba na le li-*microbiome* tse fapa-fapaneng ho feta batho ba phelang litoropong le linaheng tse tsoetseng pele tlhahisong le moruong.



Mosali oa  
Leamerika,  
naheng ea  
Amerika



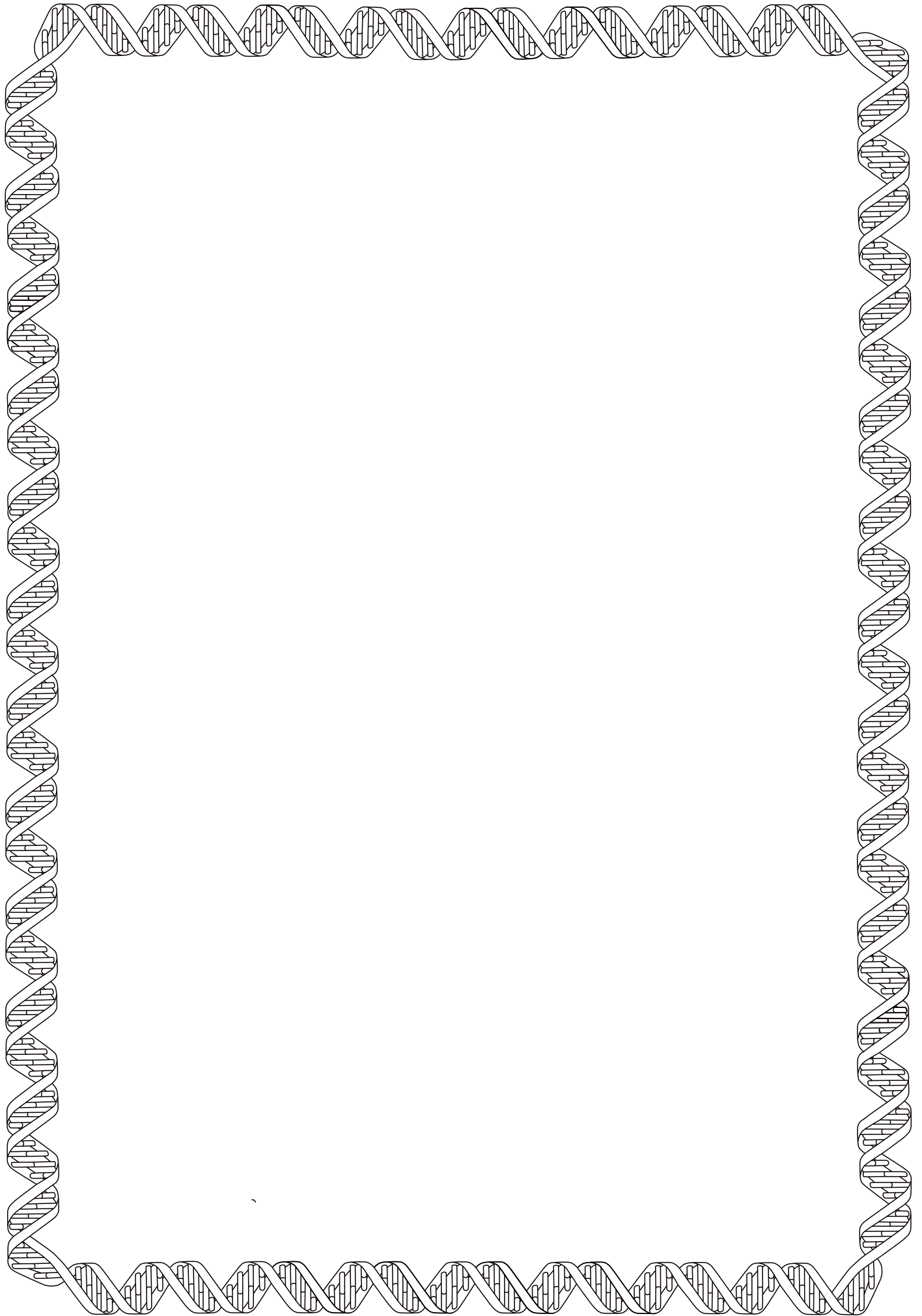
'M'e oa Mo-Hadza  
le ngoana, naheng  
ea Tanzania

## LINAHENG TSE TSOETSENG PELE TLHAHISONG LE MORUONG

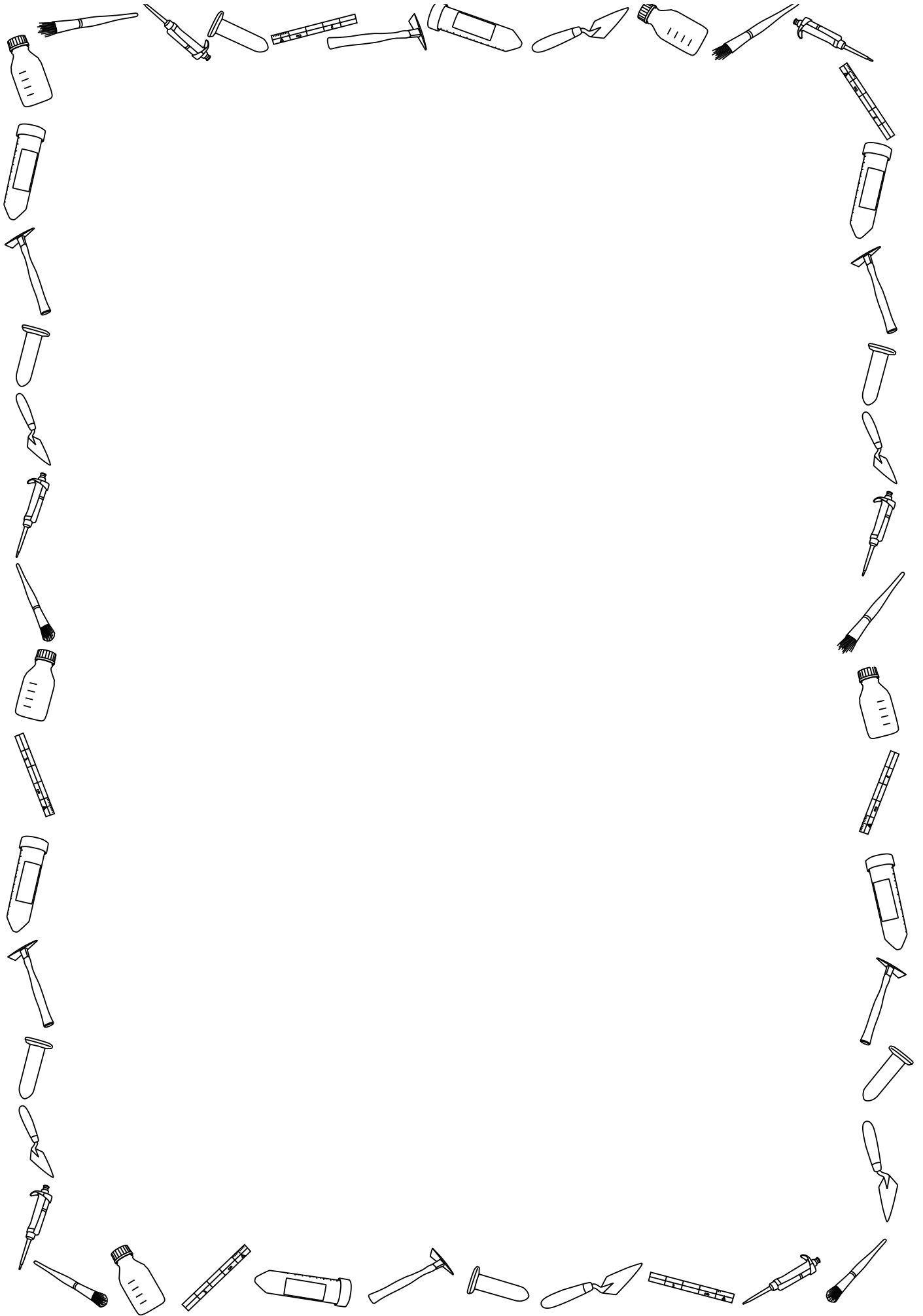
Linaheng tse tsoetseng pele tlhahisong le moruong, ho jeoa lijo tse hlahisitsoeng ka mokhoa oa temo, 'me ho hlahisa lijo ke tsebo ea batho ba fokolang ka palo.

Mechini, poloko le polokeho ea lijo ke lintlha tse kapele-pele tlhahisong ea lijo linaheng tse tsoetseng pele moruong, 'me lijo li nka nako pele li ka jeoa.

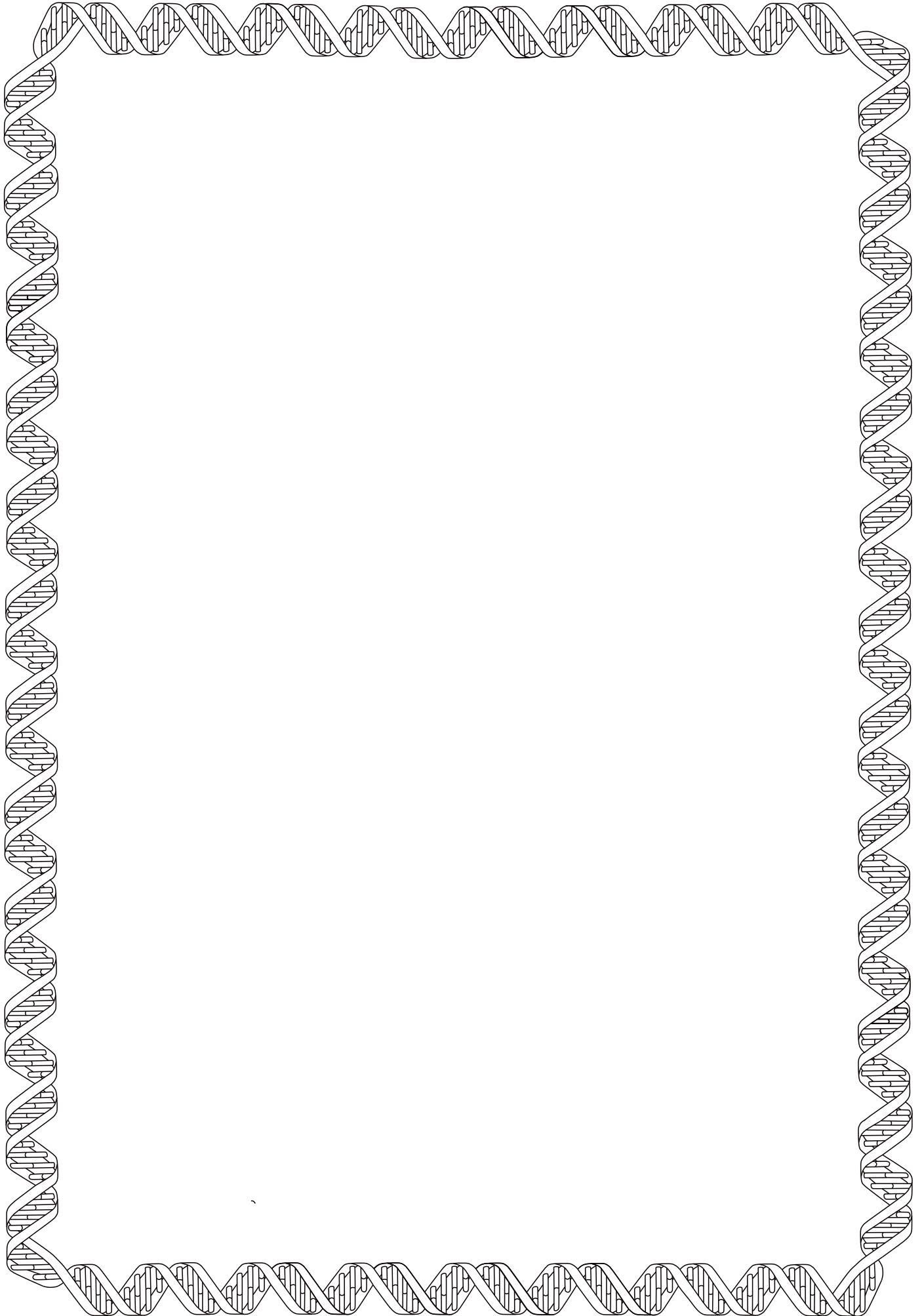
Batho ba phelang linaheng tse tsoetseng pele tlhahisong le moruong, ba iphumana ba na le li-*microbiome* tse sa fapa-fapanang, sena se ka ba beha kotsing ea mafu a mangata. Joale hopola ho kenyelletsa meroho ea Sesotho lijong tsa hao!









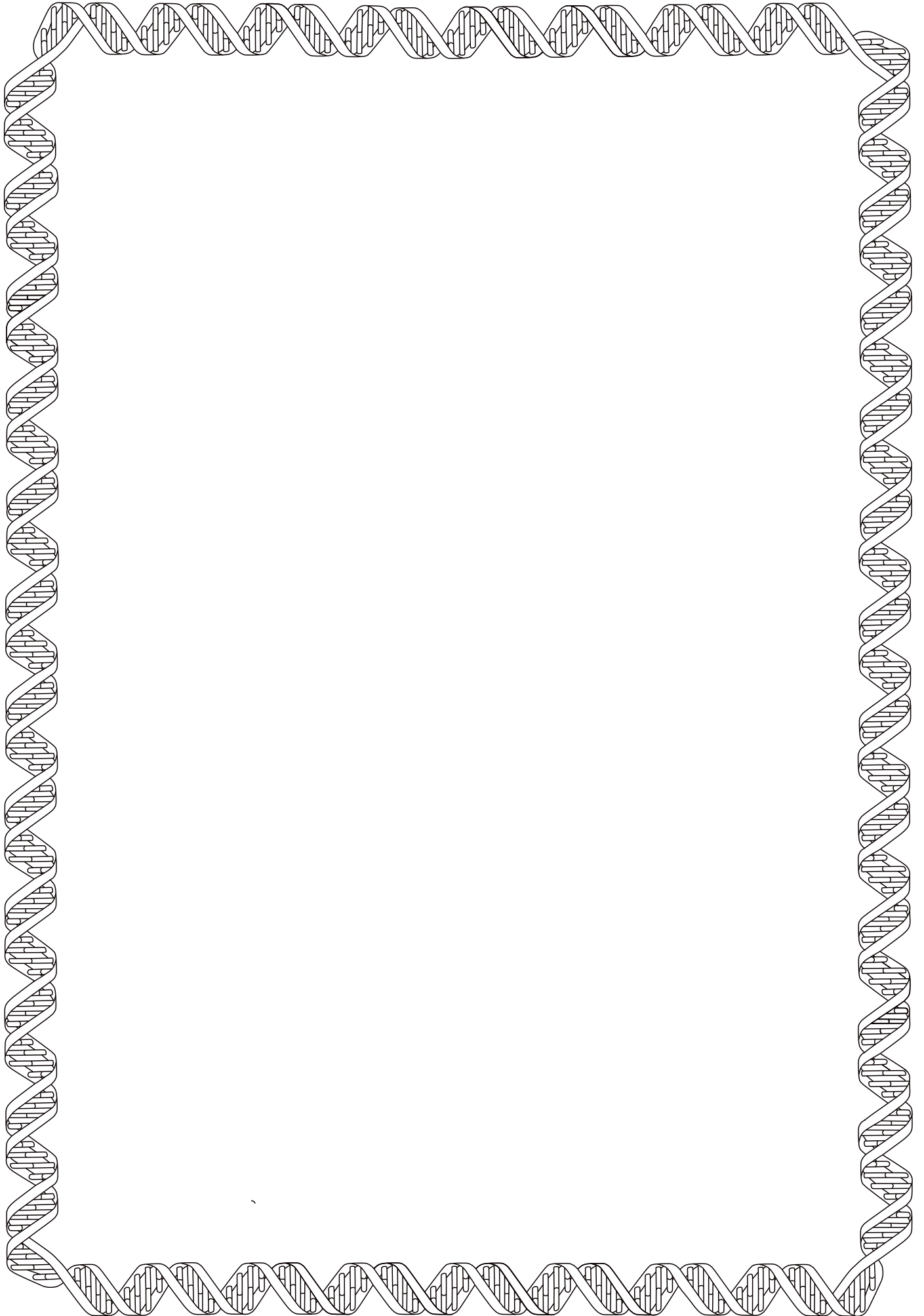






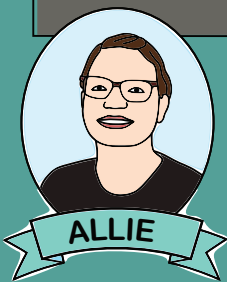




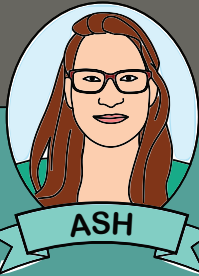




## Max Planck Institute for Evolutionary Anthropology



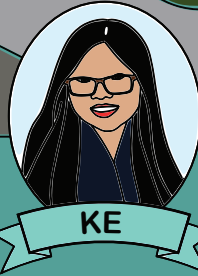
ALLIE



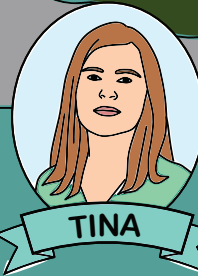
ASH



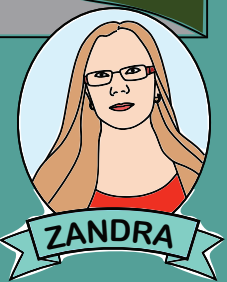
JESSIE



KE



TINA



ZANDRA

## Leeto le hlolang la

# MAHLALE A BOEPOLLI BA NALANE

## Buka ea botaki

Ithute kamoo baepolli ba lintho tsa khale le litsebi tsa mahlale ba sebetsang hammoho ho araba lipotso tse mabapi le nalane ea batho! Eba karolo ea rona ha re ithlaloa hore **re bo mang le seo re ithutang sona**, ho tloha ho **nalane ea batho** ho ea ho **mafu a nakong e fetileng**. Ithute ka **ho falla ha batho ba khale** le **radiocarbon dating**. Bona kamoo litsebi tsa mahlale li ahang **mokhoa oa ho ja** ho tsoa ho boitsebiso bo bonyane ba masalla a limela tsa tikoloho ea khale. Ribolla boitsebiso bo thahasellisang ka **thuo** le mahlale a sebelisoang ho hlahisa lijo tse entsoeng ka **lebese**. Ithute ka **mafu a boholo-holo** le **mafu a seoa** hape tseba ka **microbiome** ea baholo-holo ba rona.

E hlahisitsoe ke litsebi tsa mahlale setsing sa Max Planck sa Evolutionary Anthropology

E fetoletsoe puong ea Sesotho ke:  
Ts'episo Seisa, Ithabeleng Mokoena le  
Nthabiseng Mokoena-Mokhathi



TS'EPISO



ITHABELENG



NTHABISENG